2017

PSU Green Building Summer Internship Final Presentation, 2017

Campus Sustainability Office

PSU Green Building Summer Internship

BUILT
BUILDING SCIENCE LAB TO ADVANCE TEACHING

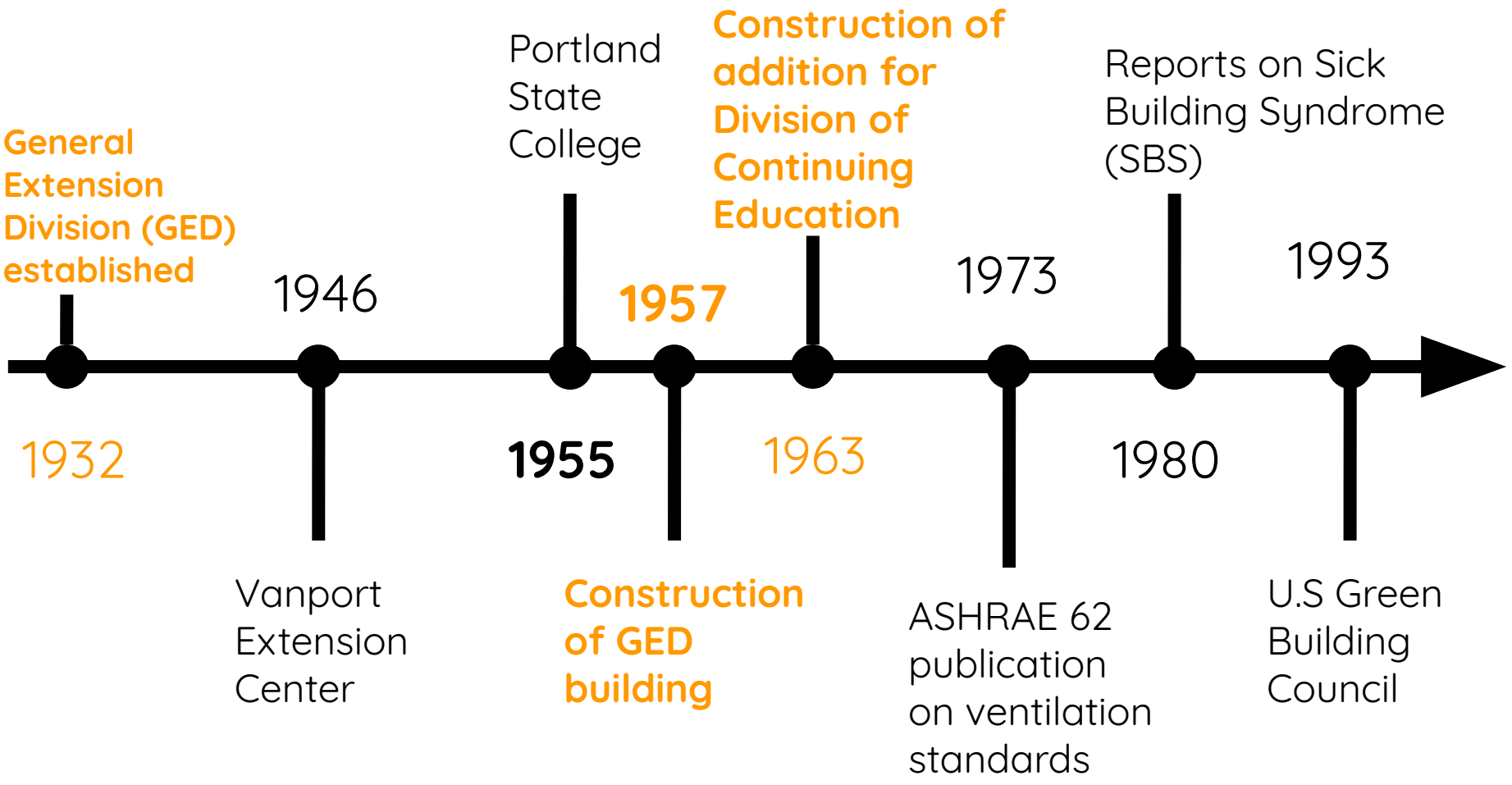
Institute for Sustainable So
PORTLAND STATE UNIVERSITY

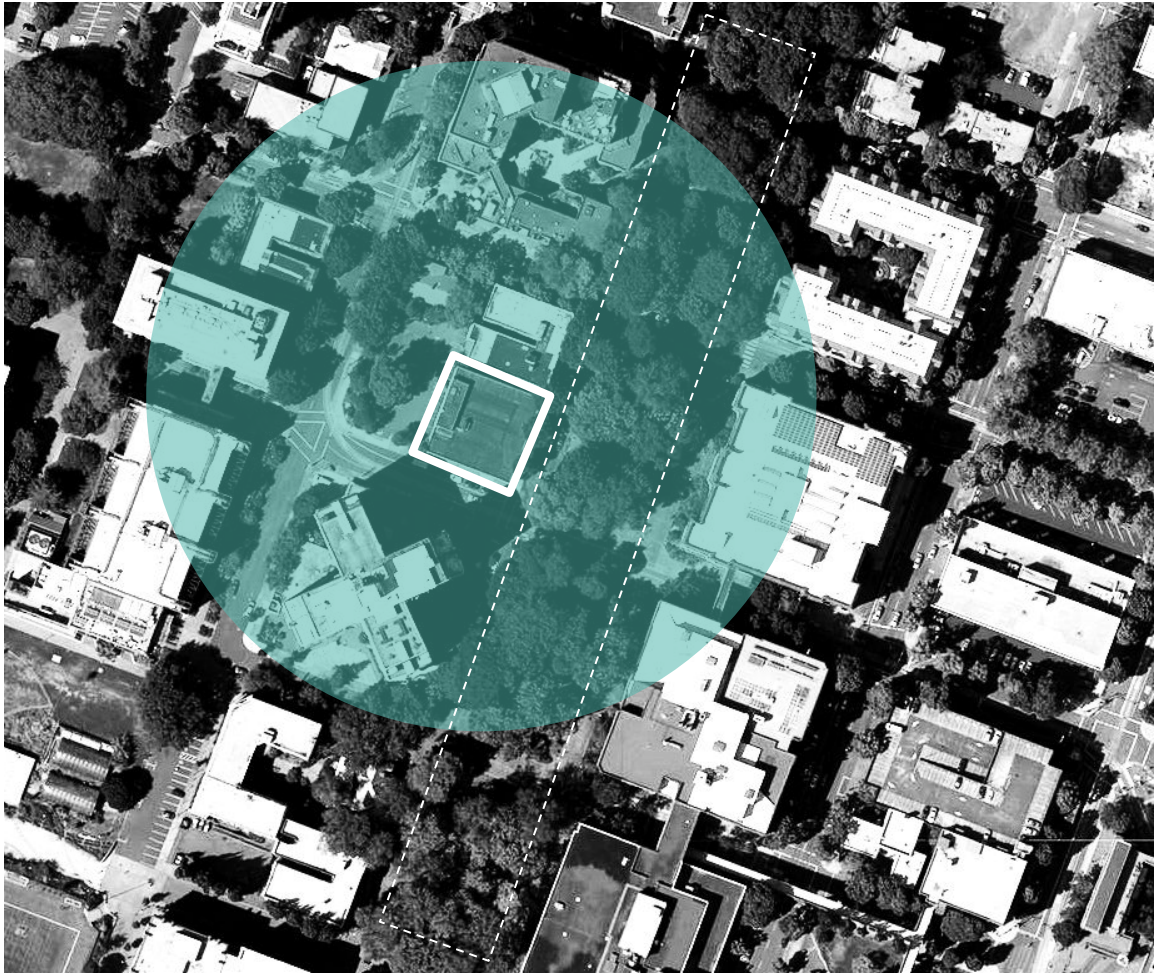
Green Building Research Laboratory
Portland State UNIVERSITY

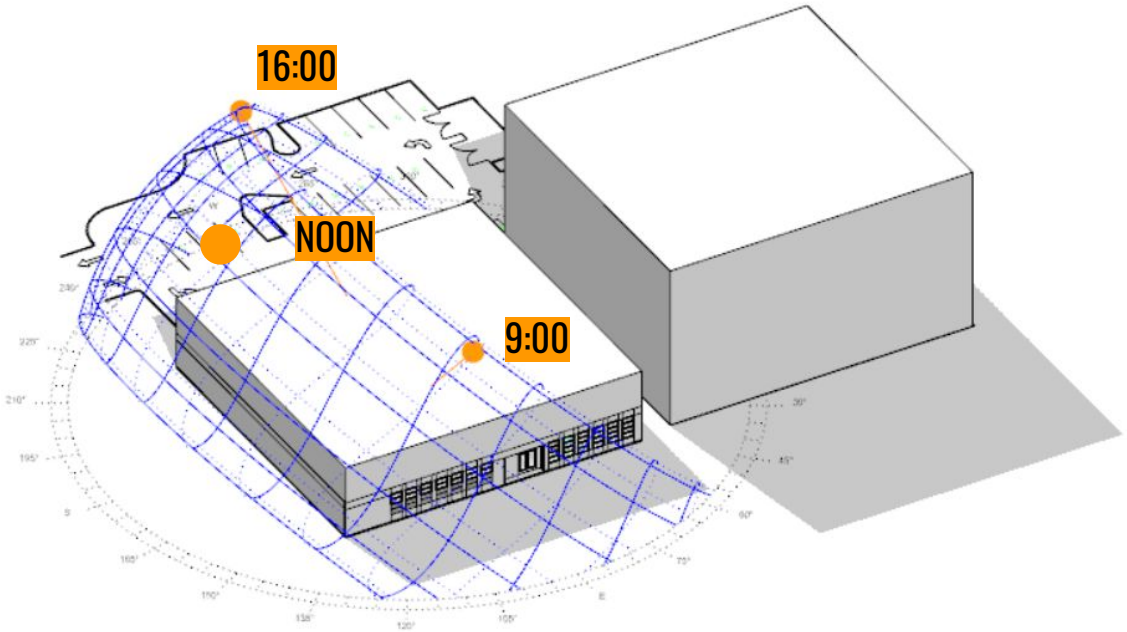
Portland State UNIVERSITY
CAPITAL PROJECTS AND CONSTRUCTION

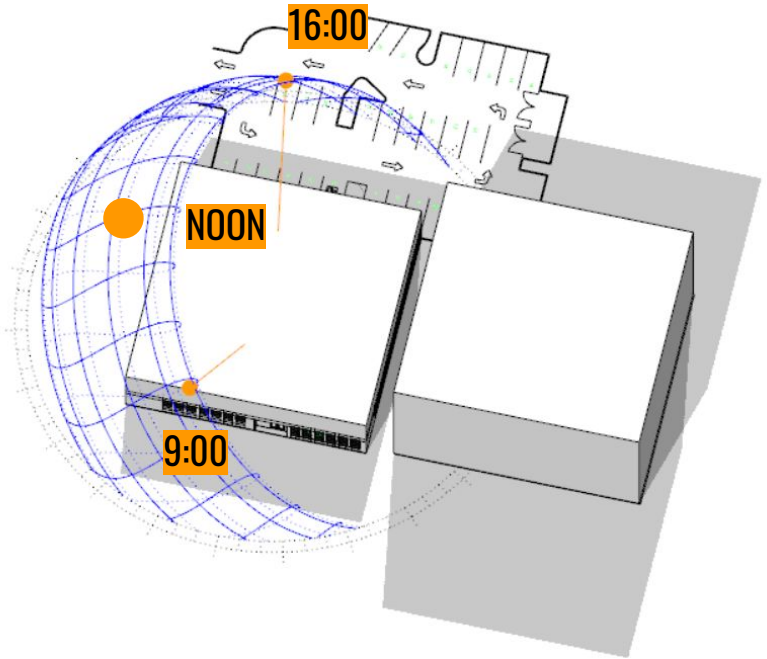
RESEARCH QUESTION:

Is duct cleaning beneficial in terms of energy efficiency and overall occupant comfort?


General Extension Division (GED) established
1932
1946
Vanport Extension Center
Portland State College
1955
Construction of GED building
1957
Construction of addition for Division of Continuing Education
1963
1973
ASHRAE 62 publication on ventilation standards
Reports on Sick Building Syndrome (SBS)
1980
1993
U.S Green Building Council




16:00
NOON
9:00


16:00
NOON
9:00

OBJECTIVES:

Interior Environmental and Indoor Air Quality Assessments of Workspaces to define Future Maintenance Procedures for Parkmill's Constant Air Volume (CAV) HVAC system.

- Analyse the Interior Environmental Quality (IEQ)
- Evaluate the duct cleaning process.
- Analyse the Indoor Air Quality (IAQ)
- Conduct a basic post occupancy evaluation.

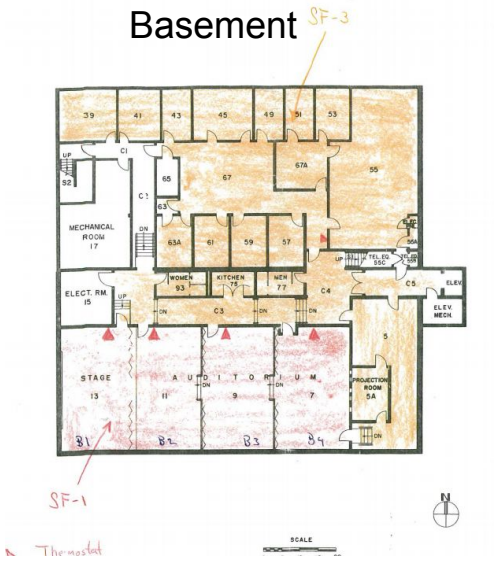
Points to consider

- Duct cleaning has never been performed in Parkmill building since it was built in 1957.
- There are no evidence that significant amount of energy will be saved considering the cost of the duct cleaning.
- Green Revolving Funds qualification.
- The University Services Building (USB) example.
- The HVAC system is CAV.

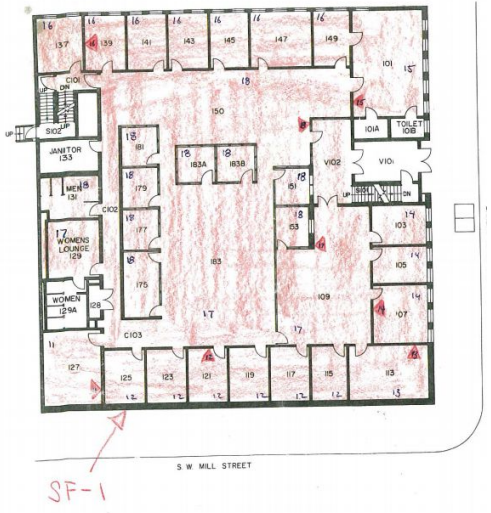
The HVAC System

- Constant Air Volume (CAV)
- 3 Supply fans. SF-1 serves the first floor and some parts of other floors

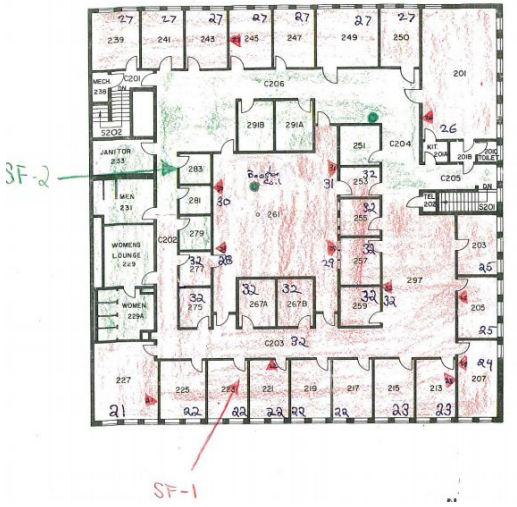
Basement



1st floor



2nd floor

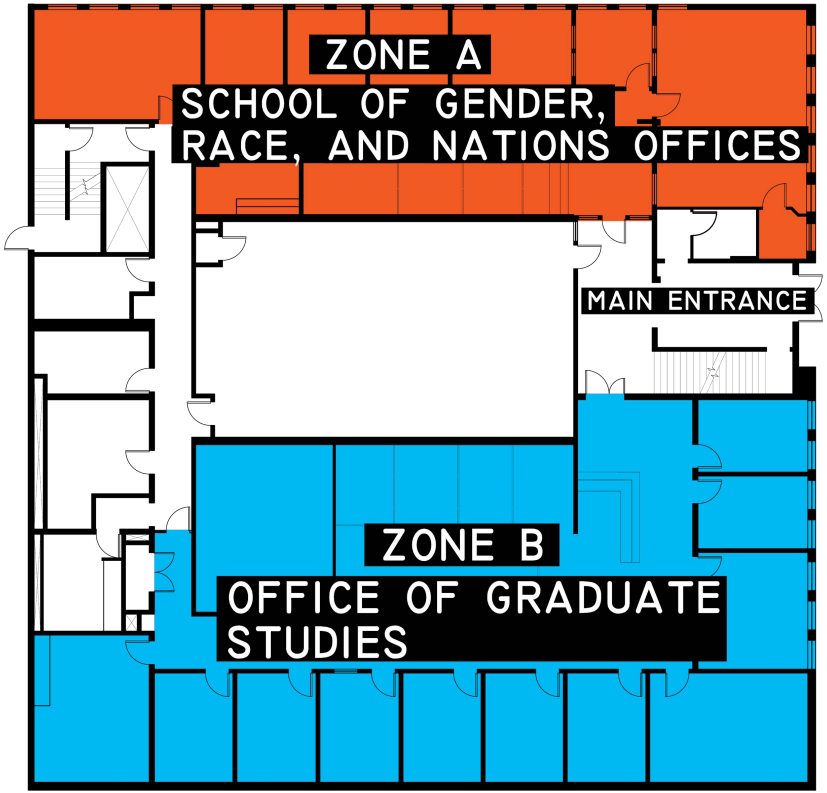


Two main zones

We decided to focus our study in the occupied spaces of the floor

We expected to to have a very close average indoor temperature and relative humidity in zones A and B.

CAV, and S-1



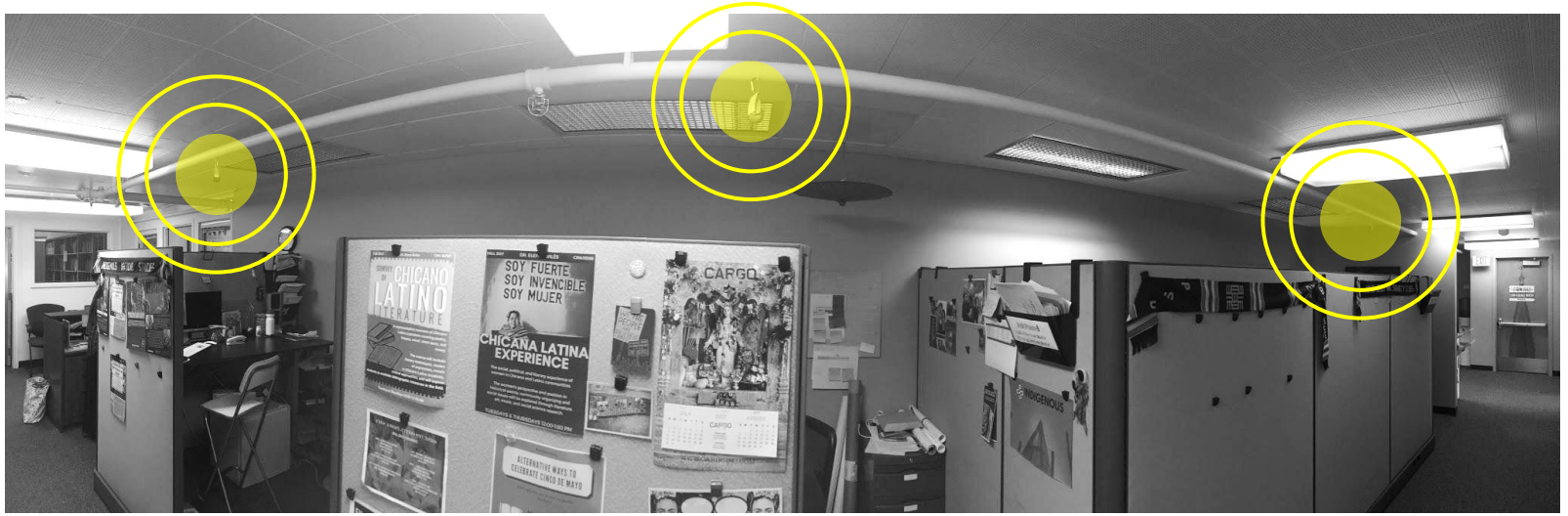
Methodology

- The Indoor Air Quality (IAQ) term is used to describe a low **pollutants** ambient air environment with a **comfortable temperature** and **relative humidity** level.
- Data will be gathered using Sensors and surveys to assess the current IAQ, and will be done again after the completion of the duct cleaning process.

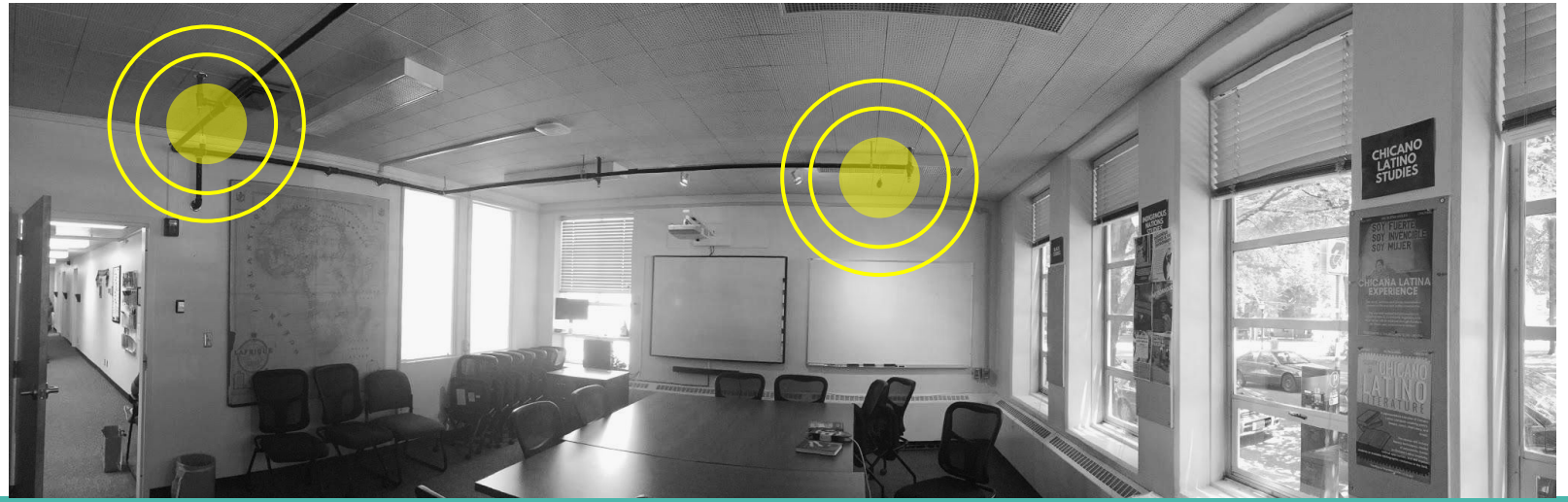
Temperature, RH, and CO2 Sensors

- Kestrel Drop data loggers
- Onset HOBO MX CO_2 Logge
- Data loggers were set to take readings every 30 min

150


CHICANO LATINO LITERATURE
SOY FUERTE
SOY INVENCIBLE
SOY MUJER
CHICANA LATINA EXPERIENCE
CARGO
ALTERNATIVE WAYS TO CELEBRATE CINCO DE MAYO
INDIGENOUS

101A


CHICANO LATINO STUDIES
SOY FUERTE
SOY INVENCIBLE
SOY MUJER
CHICANA LATINA EXPERIENCE
CHICANO LATINO LITERATURE

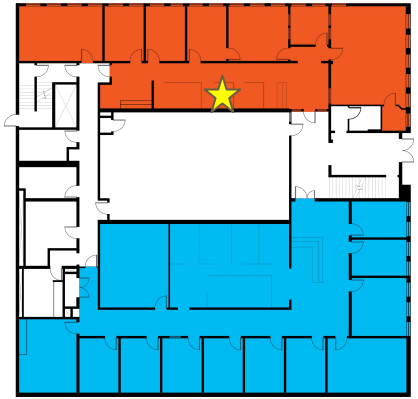
119

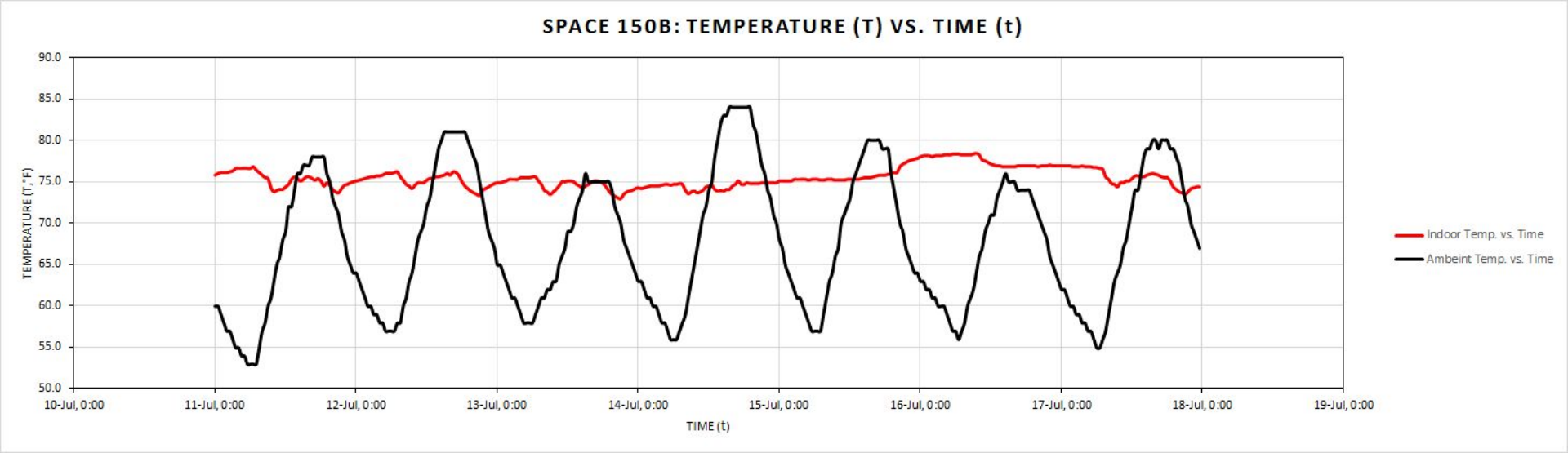
TVOC, PM, and air flow

- VOC.TraQ to measure the TVOCs, VelociCalc for air Velocity,
- And FLUKE for PM
- Mass Spectrometer.

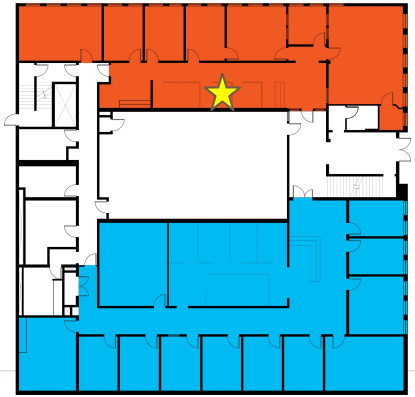

SENSOR KEY
Temperature, T (F)
relative Humidity, rH (%)
HOBO ONSET CO2 (ppm)
HOBO Occupancy/Light (lux)
SCHEDULE
Deployment: 10 July - 11 July
Data log check visit: 18 July
25 July
01 Aug
08 Aug
Sensor collection/
End of testing period: 11 Aug
2209276
137
147
150
2209060
2209172
150C
2209063
150B
2209049
150A
2209181
101
VI02
2209053
VI01
2209263
130
2159806
C104
184B
2209165
184A
2209164
184
184C
2209271
2209066
2209176
185
2209240
C105
2209252
107
2209225
123
2209163
119
2209237
2209184
113

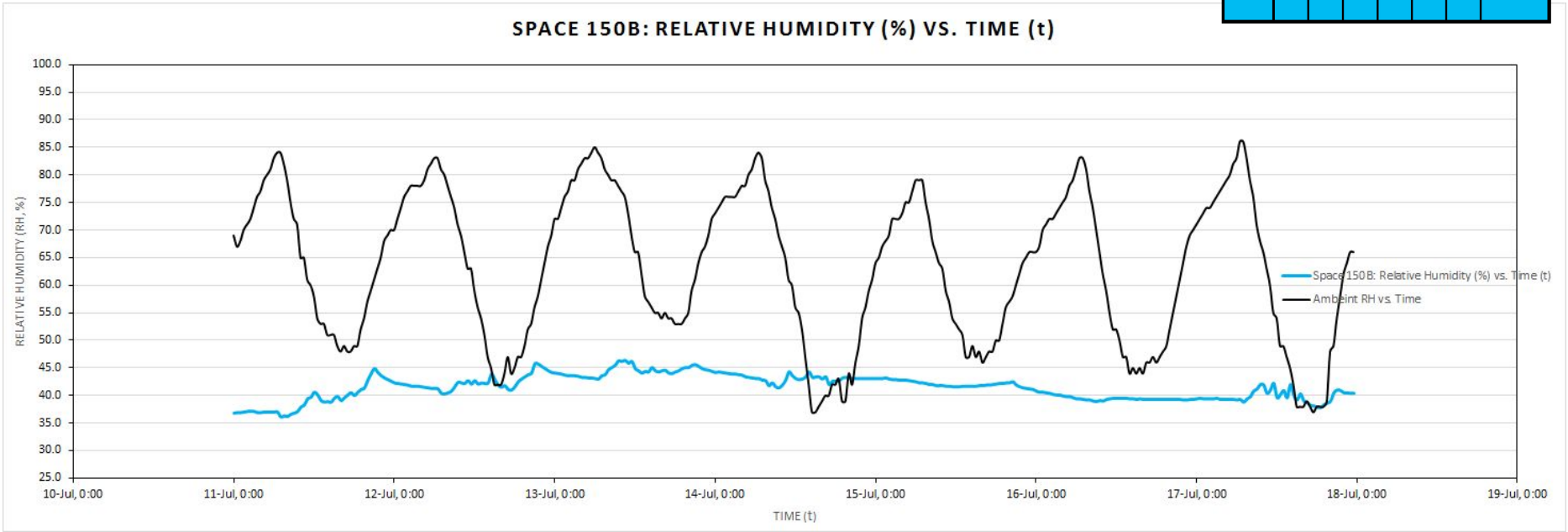
Preliminary results



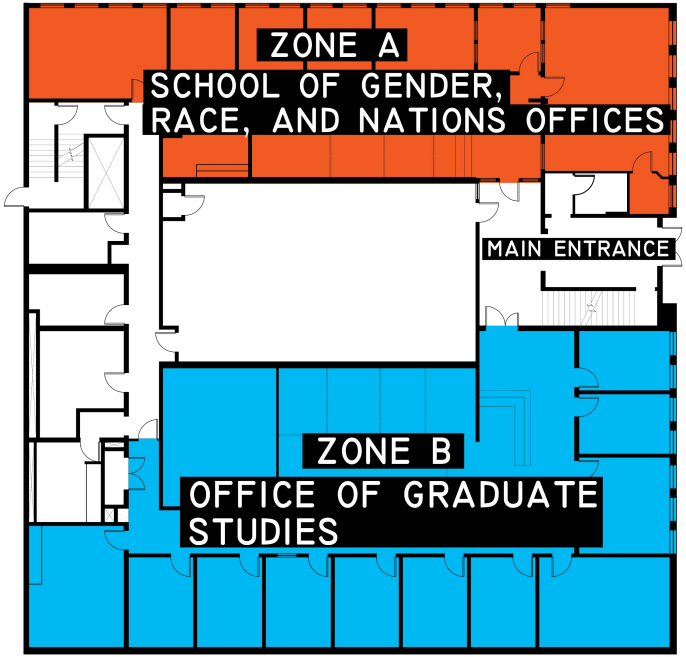


Kestrels results

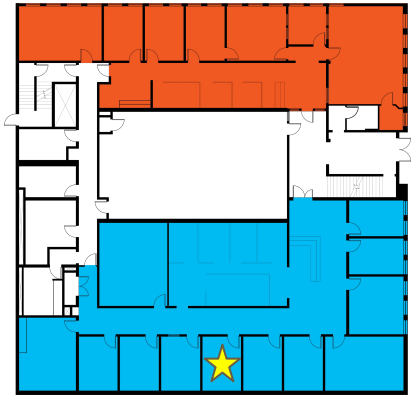


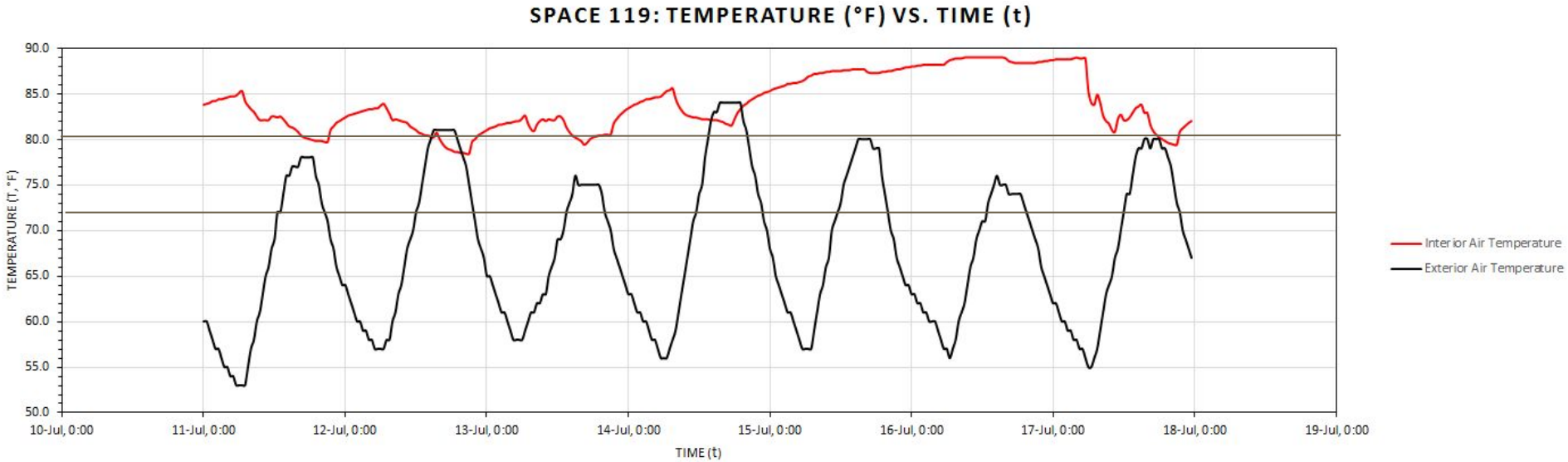


What about Zone B ?

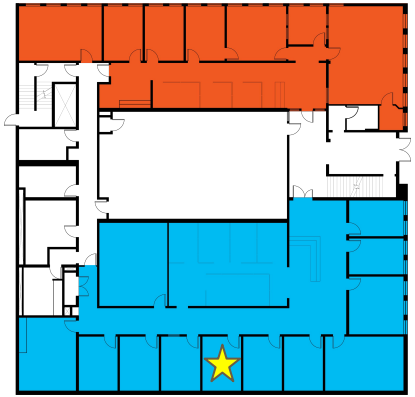


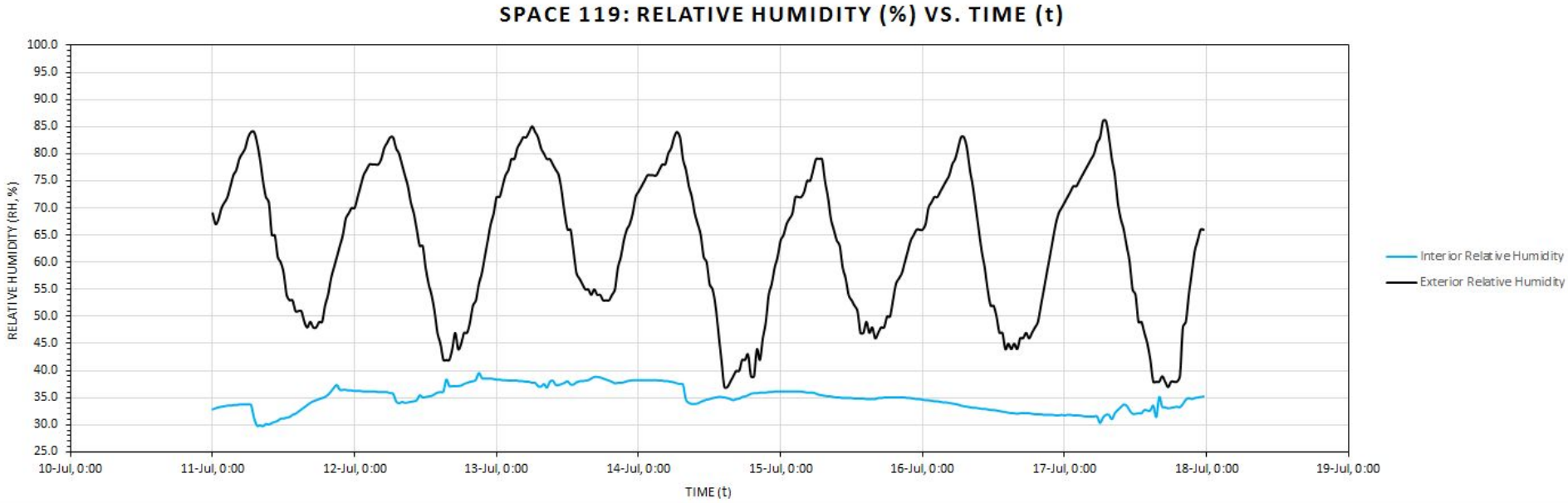
Preliminary results





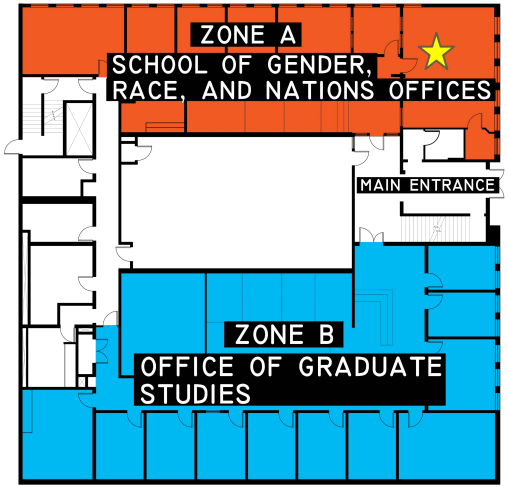
Preliminary results





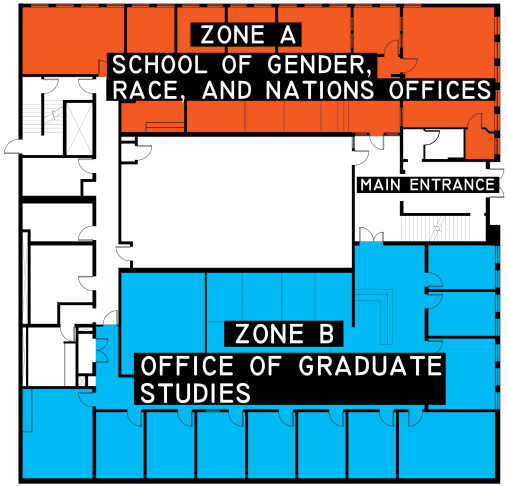
Maximum Temperature and RH Zone A vs. Zone B

	Zone A				Zone B	
Space	**Max. Temp. (F)**	**Max. RH (%)**		**Space**	**Max. Temp. (F)**	**Max. RH (%)**
150A	78.3	45.7		**107**	79.4	46.8
150B	78.4	46.3		**113A**	80.2	42.9
150C	77.7	46		**113B**	80.9	40.5
101A	76.3	53.5		**119**	89	39.6
101B	76.2	52.1		**123**	83.5	41.1
141	77.7	50.1		**184A**	79.2	44.9
				184B	79.3	45.4
				184C	79.5	45.3
				185	78.9	50.7
				C104	80.4	44
Average	**77.4**	**49.0**			**81.0**	**44.1**



Average Temperature and RH Zone A vs. Zone B

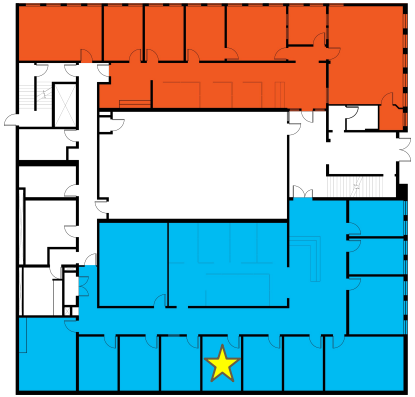
	Zone A				Zone B	
Space	**Avg. Temp. (F)**	**Avg. RH (%)**		**Space**	**Avg. Temp. (F)**	**Avg. RH (%)**
150A	75.5	41.3		**107**	75.5	40.6
150B	75.5	41.4		**113A**	78.1	38.7
150C	75.5	41.3		**113B**	79.1	37.2
101A	72.1	46.2		**119**	84	35
101B	72.3	45.6		**123**	80.4	37.5
141	74.9	41.6		**184A**	76.4	40.5
				184B	76.5	40.3
				184C	76.6	40.3
				185	74.7	43.1
				C104	77.1	39.5
Average	**74.3**	**42.9**			**77.8**	**39.3**

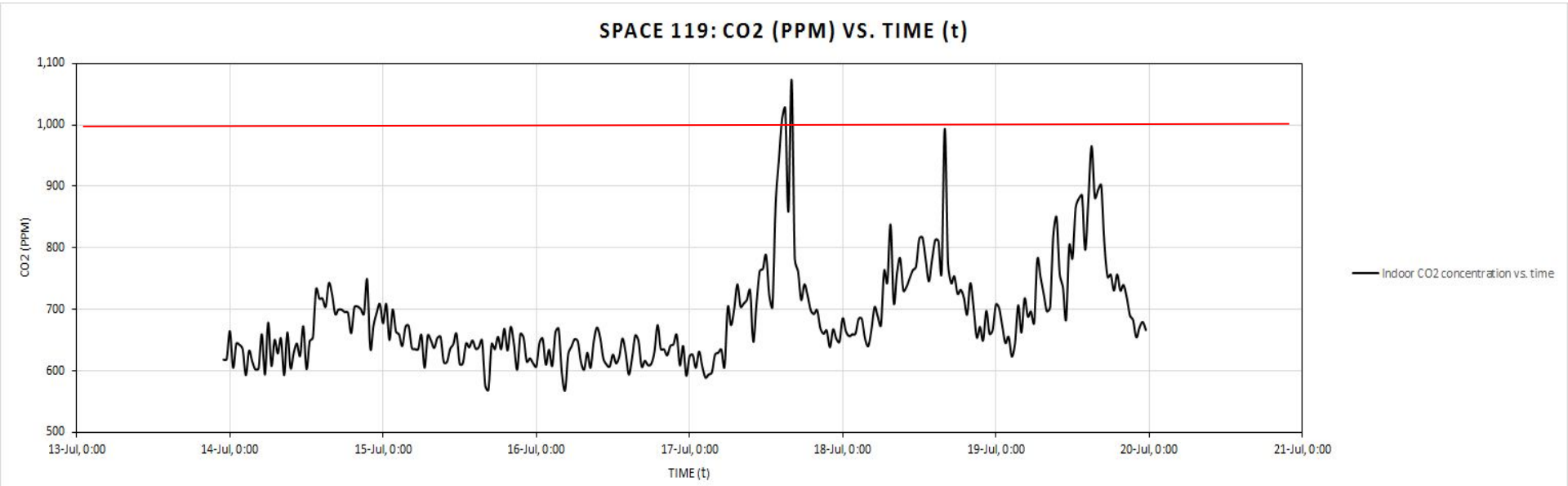


HOBOs Maximum CO_2 results

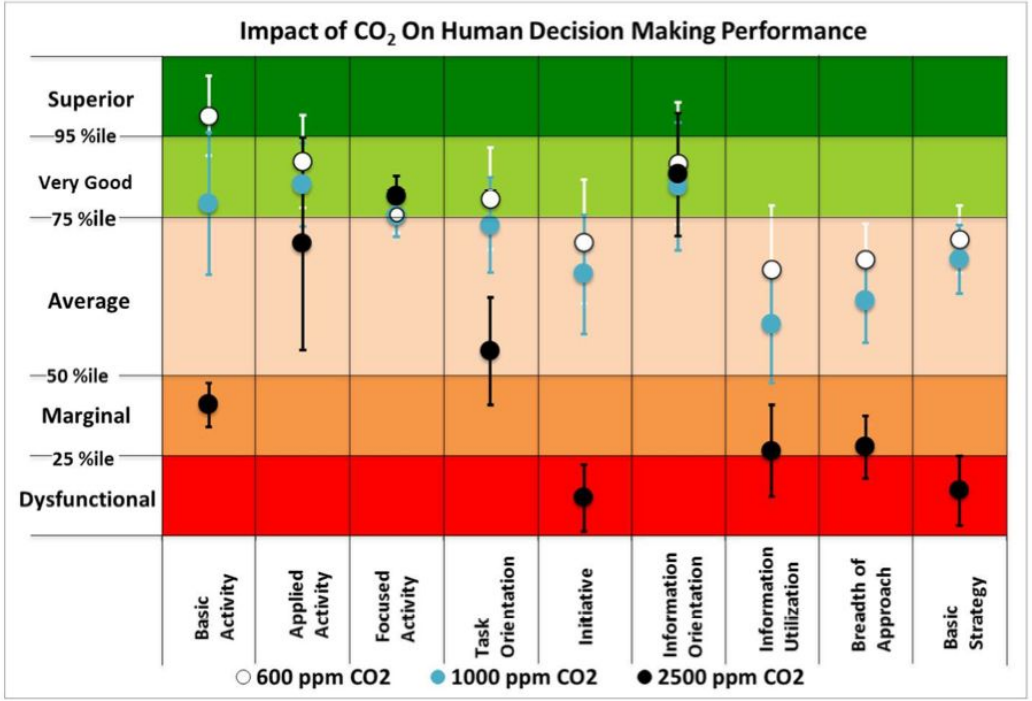
HOBOs			
Space	**Temp, °F**	**RH, %**	**CO2, ppm**
113	80	41.83	836
119	**89.32**	**41.39**	**1,072.00**
150	77.2	49.26	790
184	75.9	51.06	747

Space 119 CO2 levels

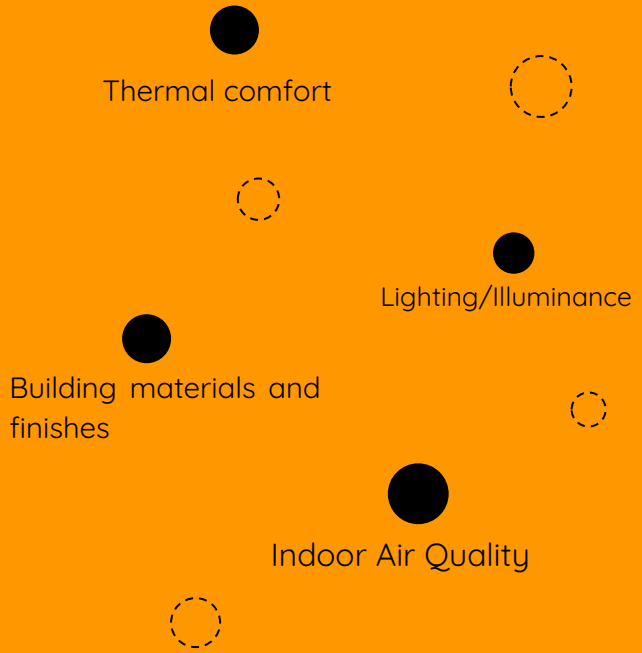




CO2 level vs performance

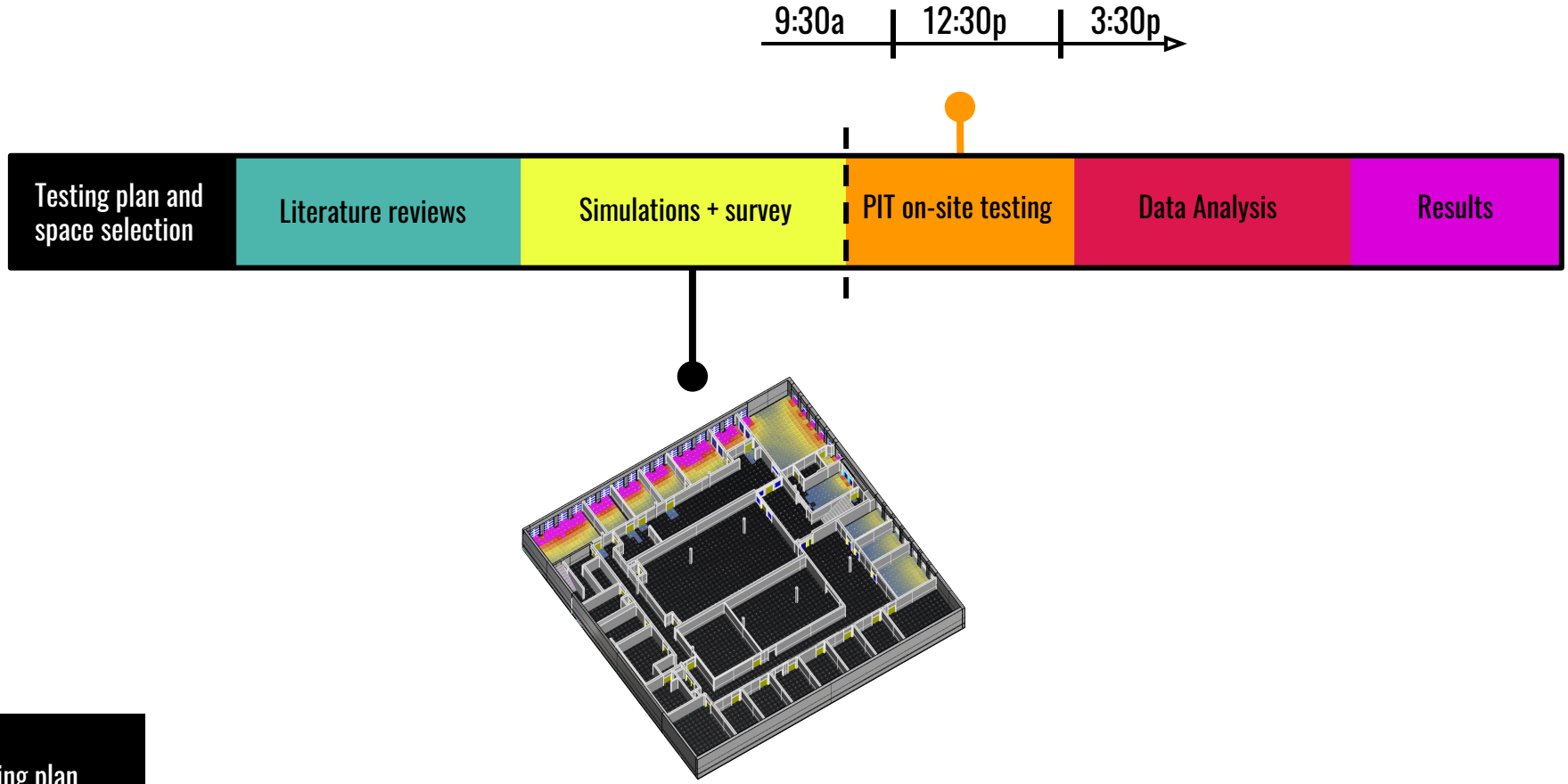


Methodology

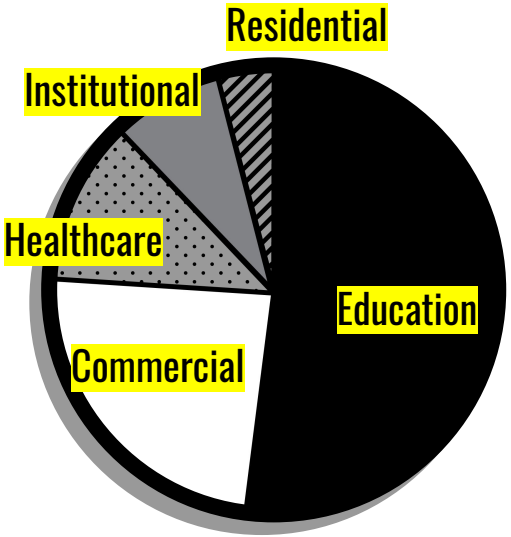


Methodology

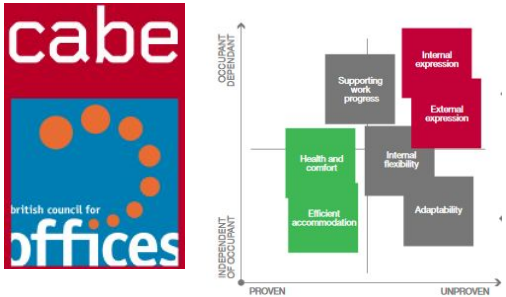
Indoor Environmental Quality (IEQ)



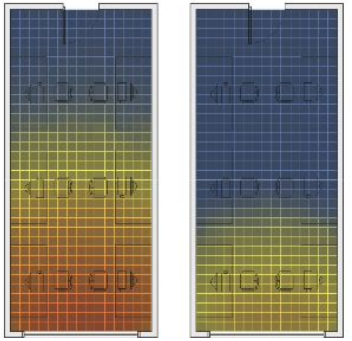
Testing plan

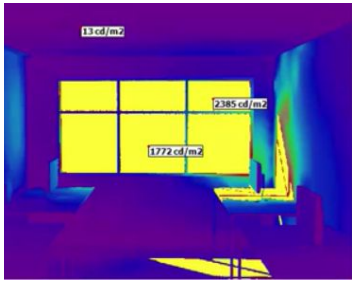


Finding value in Post Occupancy Evaluations



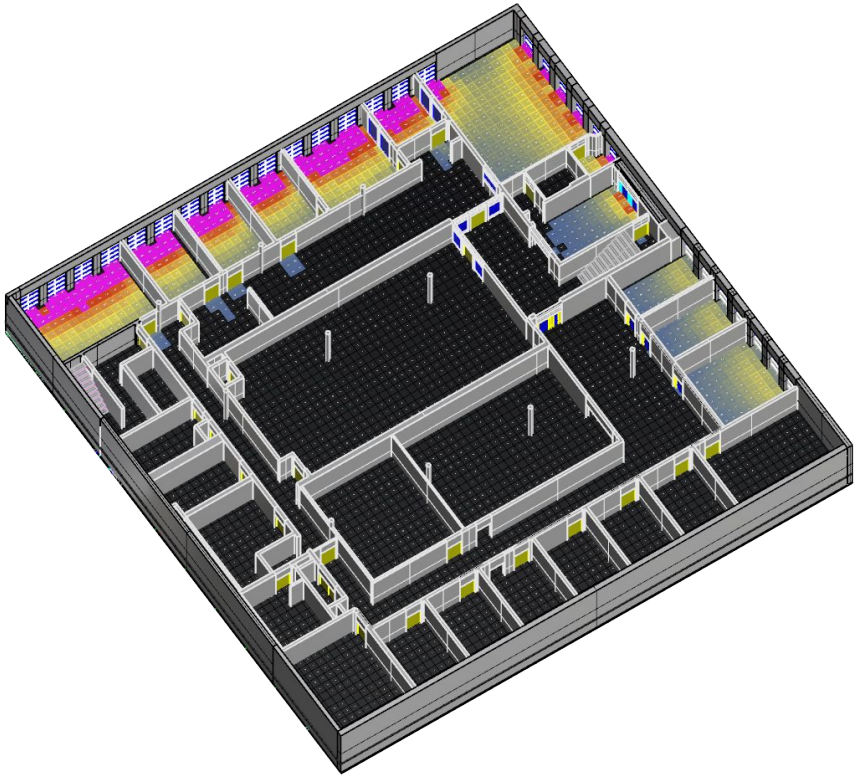
Materials



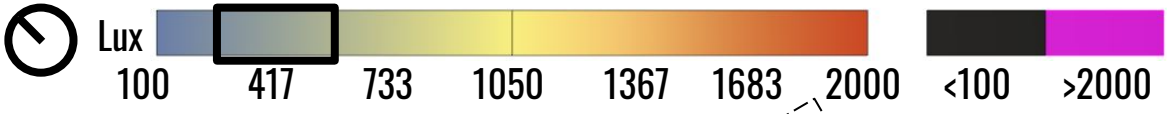


Illuminance
Daylighting + Artificial Lighting

Literature Research:
IEQ + Occupant Satisfaction



12:30p



- North Glazing material type
- East facade trees; “shading”
- Artificial lighting measurements

DIVA simulations and diagram

Sample of the survey questions

During the summer, I find that the air temperature in my work space is:

- ○ Hotter than the outside temperature
- ○ Slightly warmer than the outside temperature
- ○ About the same as the outside temperature
- ○ Slightly cooler than the outside temperature
- ○ Colder than the outside temperature
- ○ I have not noticed a difference between the air temperature inside my work space and the external air temperature

During what days in the week do you experience (in your work space) temperatures that you consider to be uncomfortably hot? Select all that apply.

- ☐ Monday
- ☐ Tuesday
- ☐ Wednesday
- ☐ Thursday
- ☐ Friday
- ☐ Weekends (if applicable)
- ☐ Daily
- ☐ I have not experienced this situation in my work space

Please rate your satisfaction with the air temperature in your work space during the past month.

Extremely satisfied	Moderately satisfied	Neither satisfied nor dissatisfied	Moderately dissatisfied	Extremely dissatisfied
○	○	○	○	○

How would you describe the impact of air temperature on your productivity and ability to work efficiently.

Extremely positive	Moderately positive	Neither positive nor negative	Moderately negative	Extremely negative
○	○	○	○	○

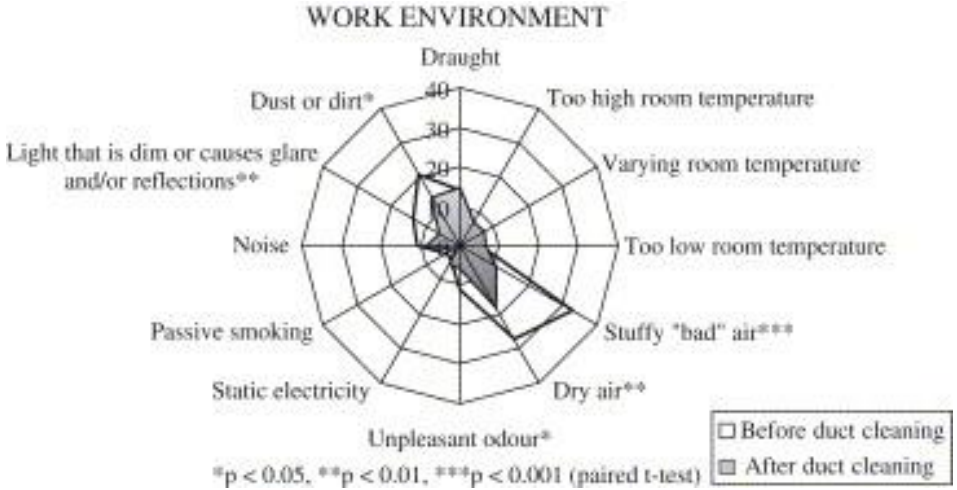
During the past month, have you used a personal space heater or personal cooling device (e.g fan)?

- ○ personal space heater
- ○ personal cooling device (e.g fan)
- ○ both

Survey Implementation

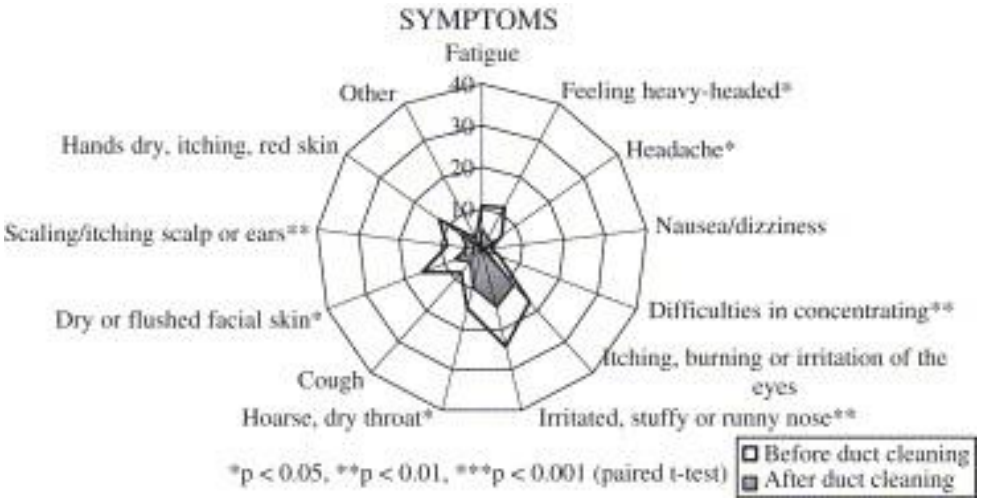
Literature reviews on duct cleaning effects

“The effect of duct cleaning on perceived work environment and symptoms of office employees in non-problem buildings”

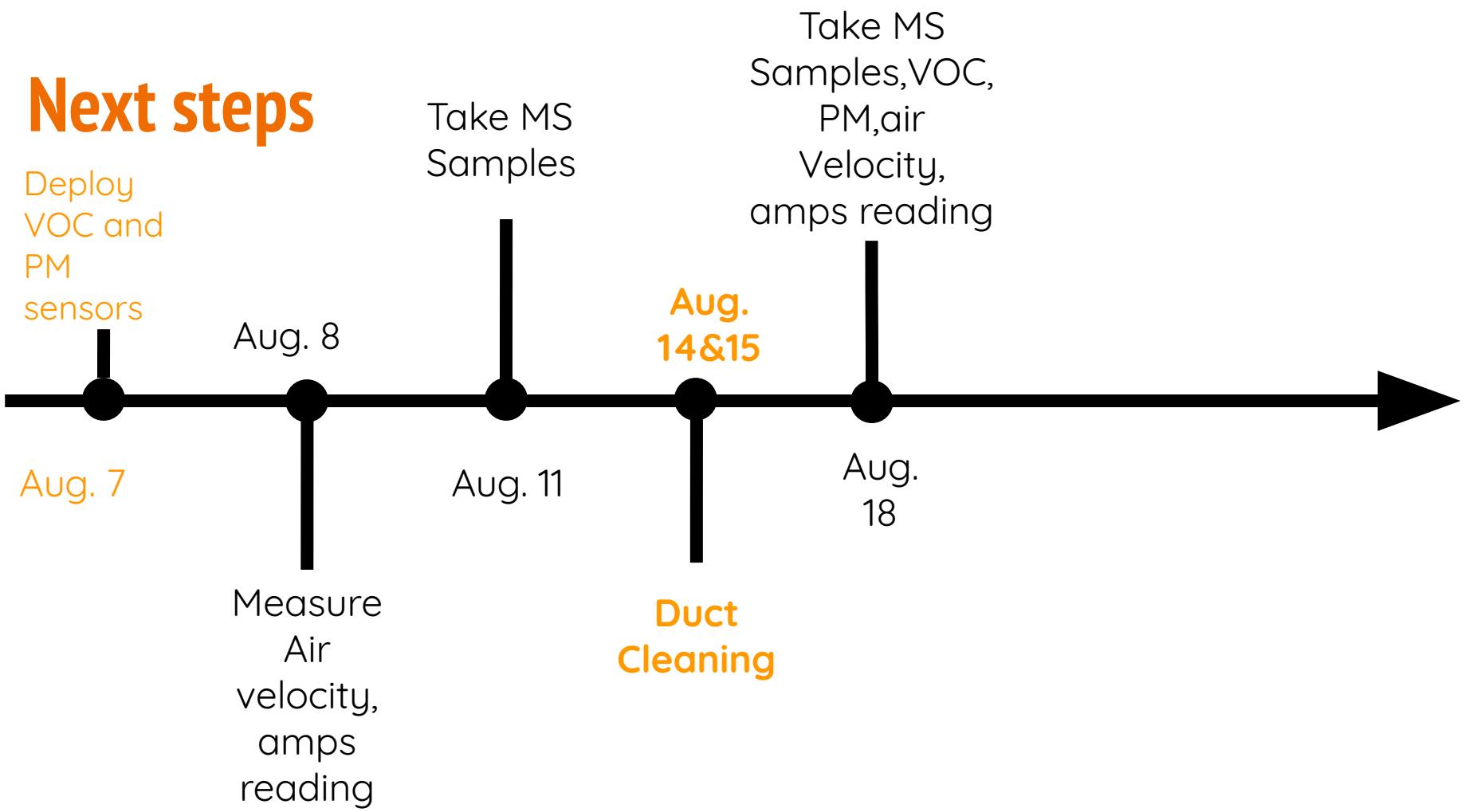


Literature reviews

“The effect of duct cleaning on perceived work environment and symptoms of office employees in non-problem buildings”



Next steps


Deploy VOC and PM sensors
Aug. 7
Aug. 8
Measure Air velocity, amps reading
Take MS Samples
Aug. 11
Aug. 14&15
Duct Cleaning
Take MS Samples,VOC, PM,air Velocity, amps reading
Aug. 18

Duct Cleaning

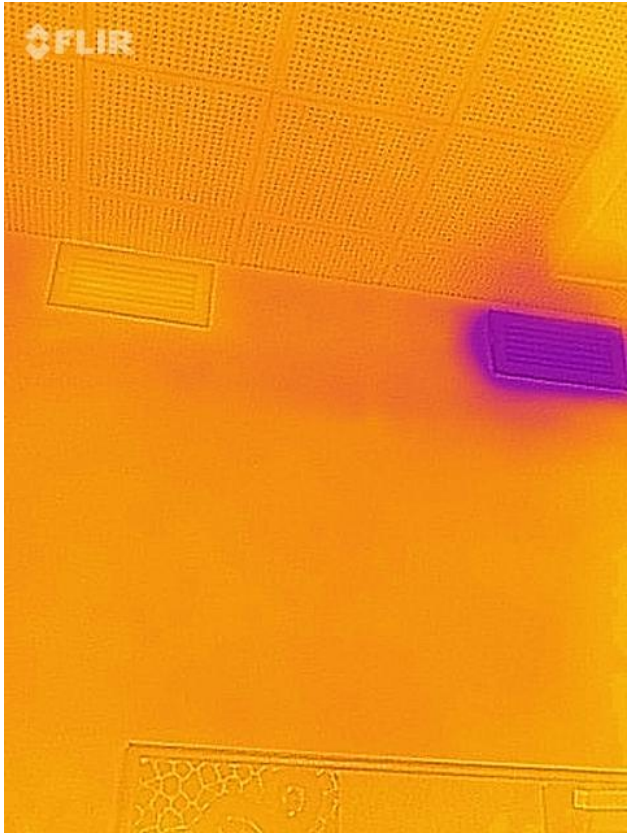
Duct Cleaning

Energy usage

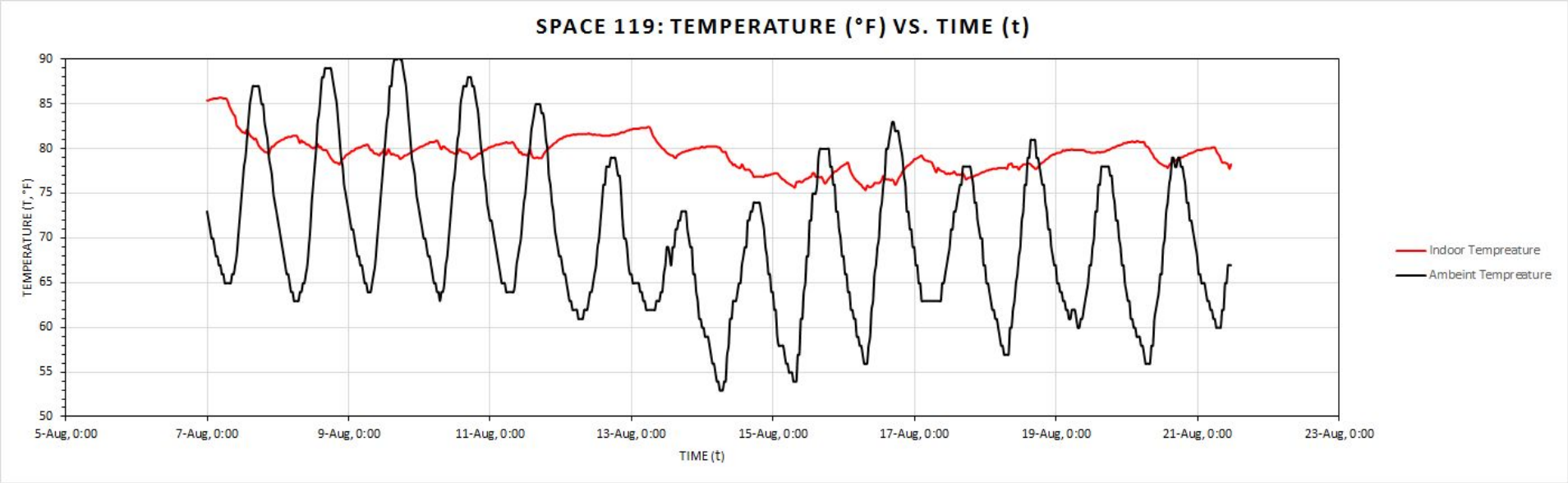
Supply fan 1		
#	Before (amps)	After (amps)
A	22.2	24.2
B	23.6	23.7
C	26.6	24.8
Avg.	24.13	24.23

RAF 1		
#	Before (amps)	After (amps)
A	17.9	17.8
B	17.1	17.5
C	16.9	17.4
Avg.	17.30	17.57

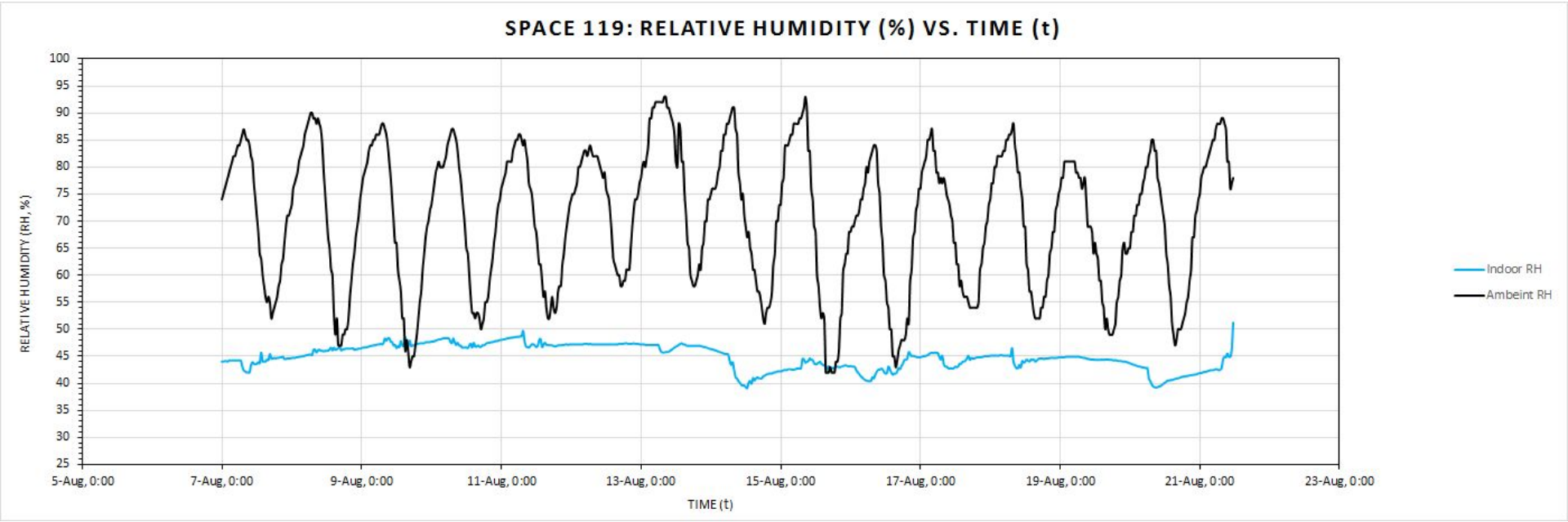
Thermal images



Temperature

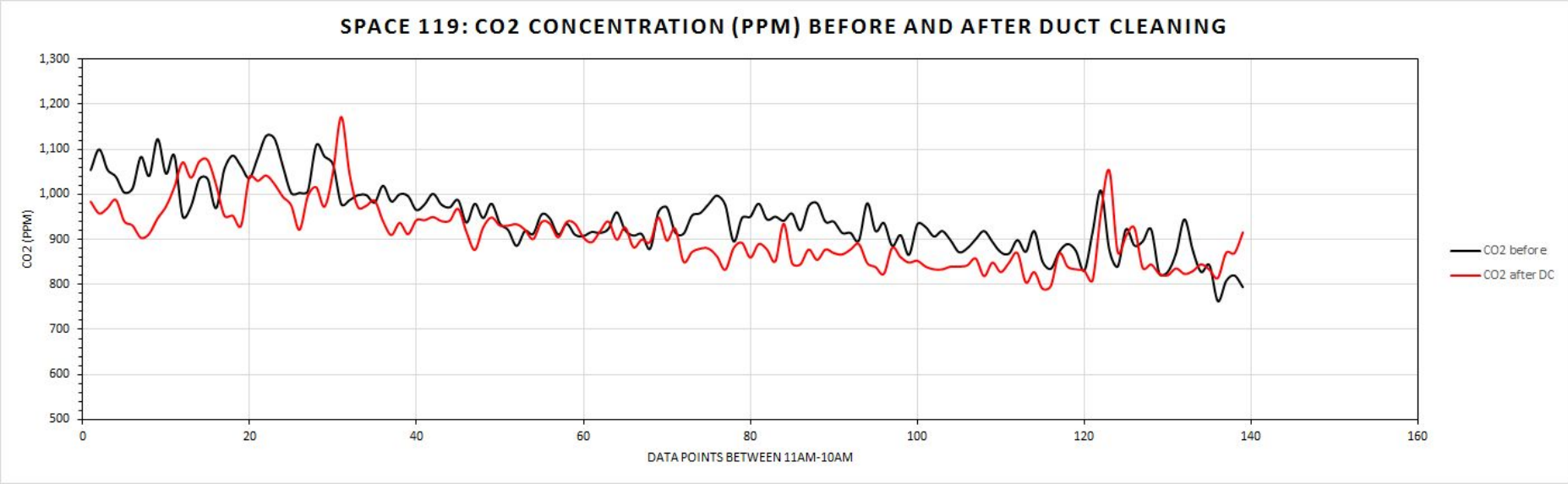


Relative Humidity



CO2

The data was taken on August 9th and 23rd from 11am-10am



Particulate Matters

WHAT ARE THE HEALTH RISKS OF PARTICULATE MATTER?

Particulate matter poses a serious health risk because it can travel into the respiratory tract. PM2.5 is especially dangerous because it can penetrate deep into the lungs and sometimes even into the bloodstream.

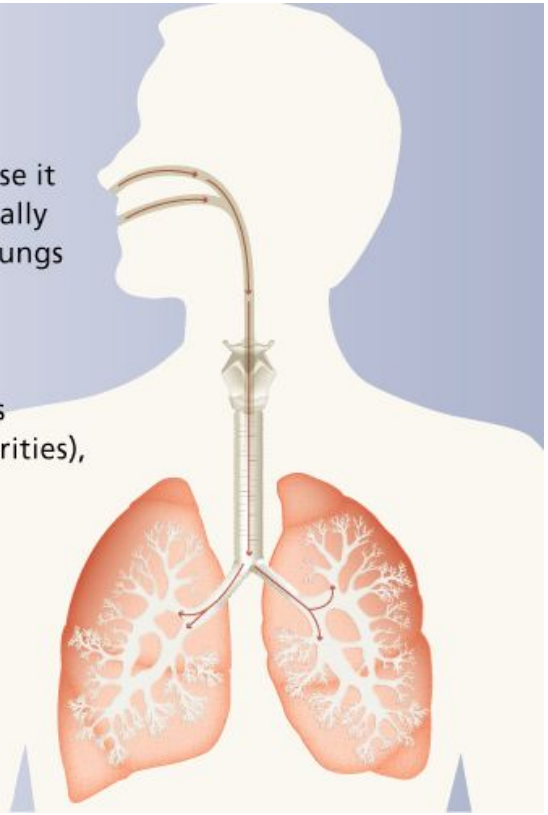
HEALTH EFFECTS

- Decreased lung function
- Chronic bronchitis
- Increased respiratory symptoms
- Cardiac arrhythmias (heartbeat irregularities),
- Heart attacks
- Premature death

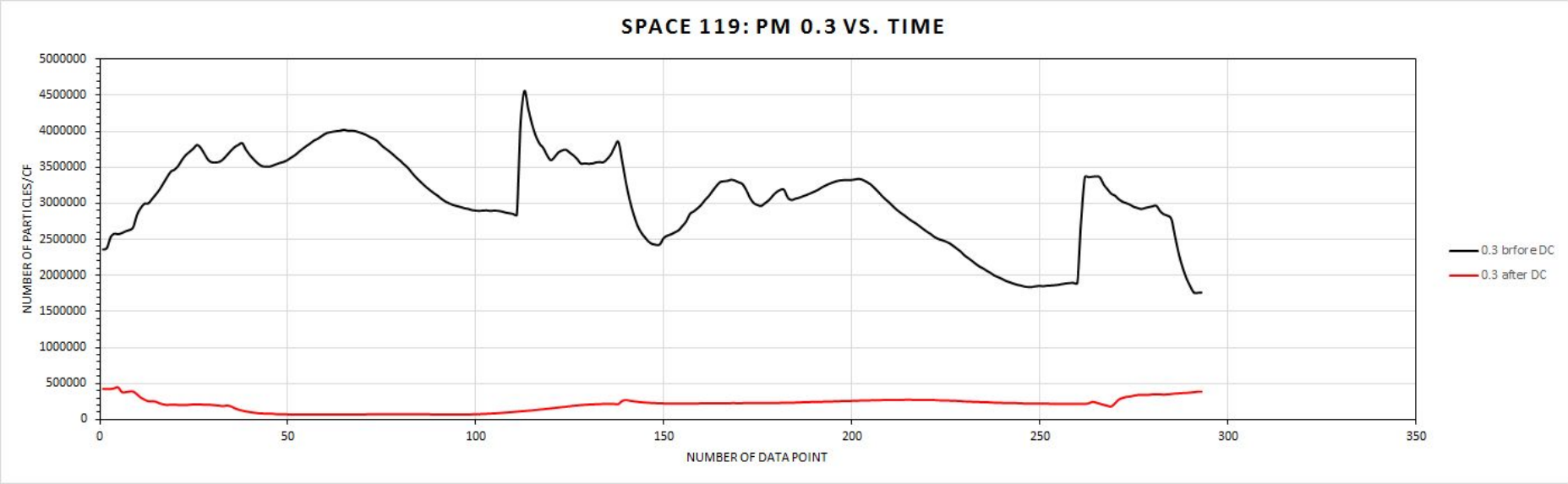
GROUPS SENSITIVE TO PM2.5

- People with heart or lung disease
- Older adults
- Children
- Pregnant women

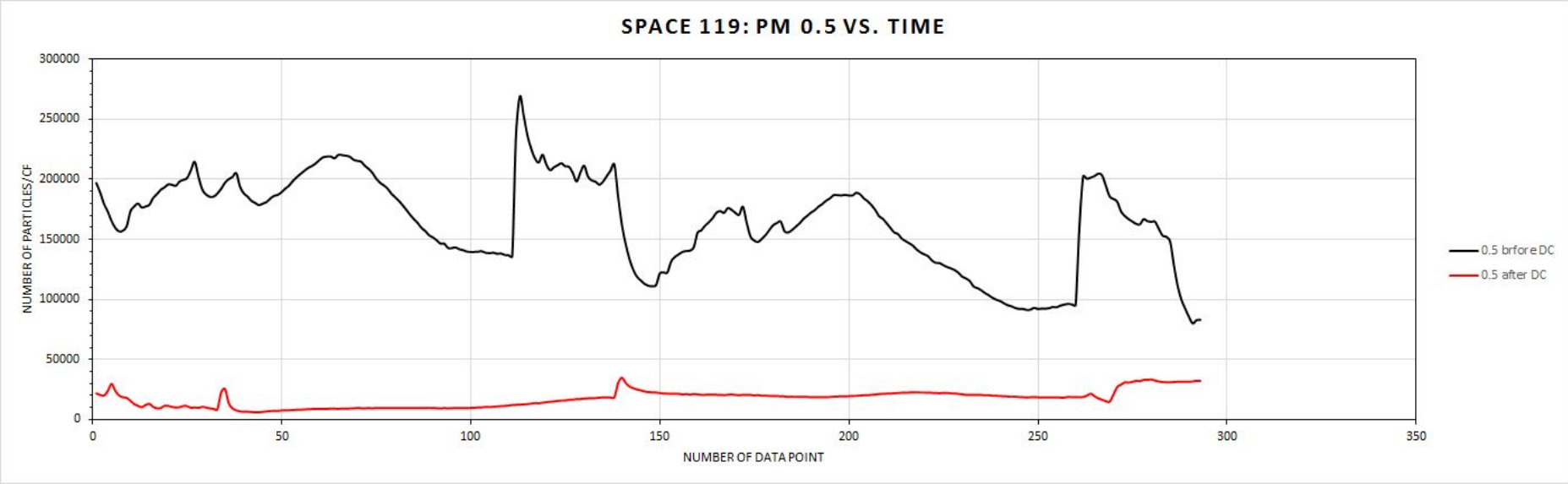
Source: www.epa.gov



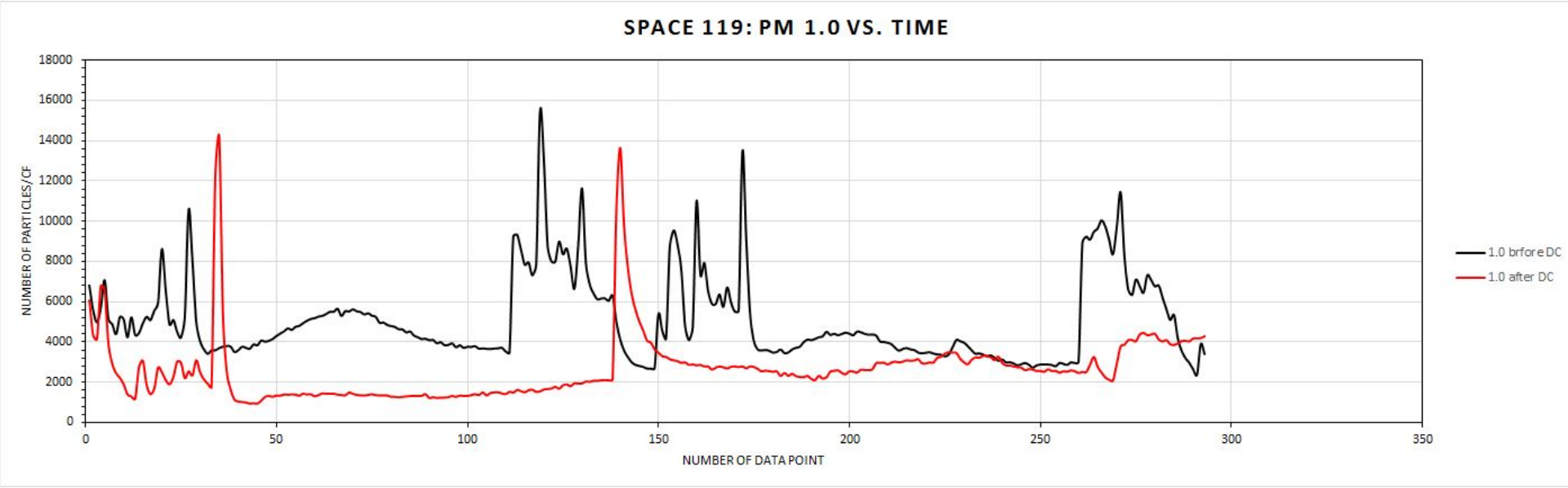
PM 0.3


SPACE 119: PM 0.3 VS. TIME
NUMBER OF PARTICLES/CF
5000000
4500000
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
0
50
100
150
200
250
300
350
NUMBER OF DATA POINT
0.3 brfore DC
0.3 after DC

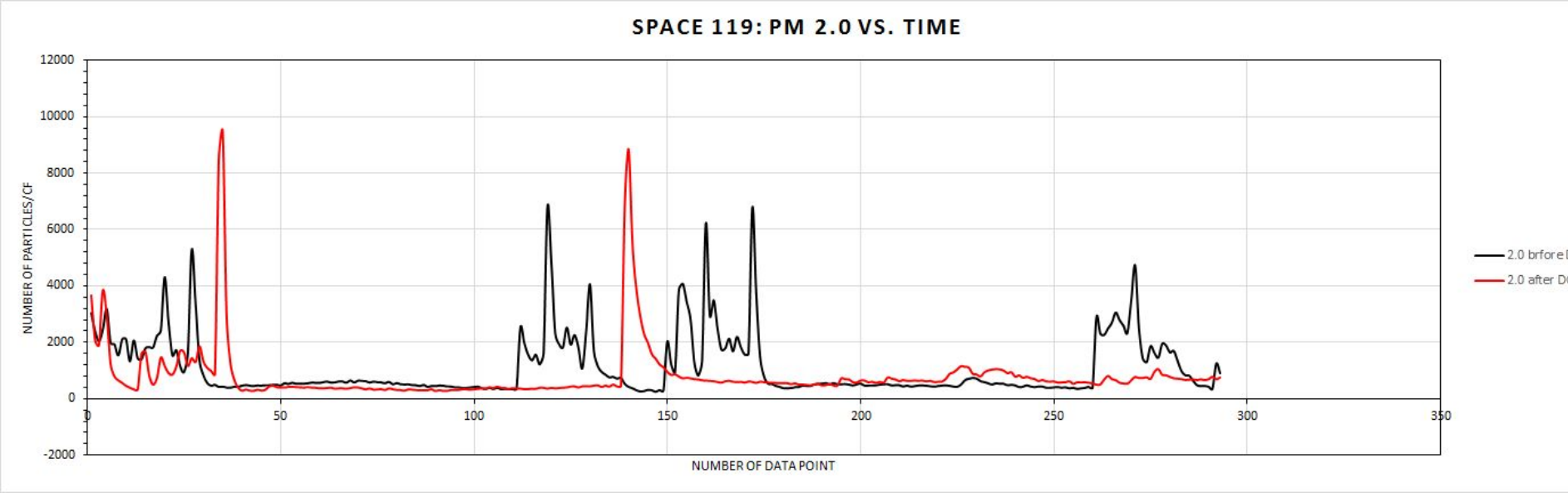
PM 0.5


SPACE 119: PM 0.5 VS. TIME
NUMBER OF PARTICLES/CF
300000
250000
200000
150000
100000
50000
0
0
50
100
150
200
250
300
350
NUMBER OF DATA POINT
0.5 brfore DC
0.5 after DC

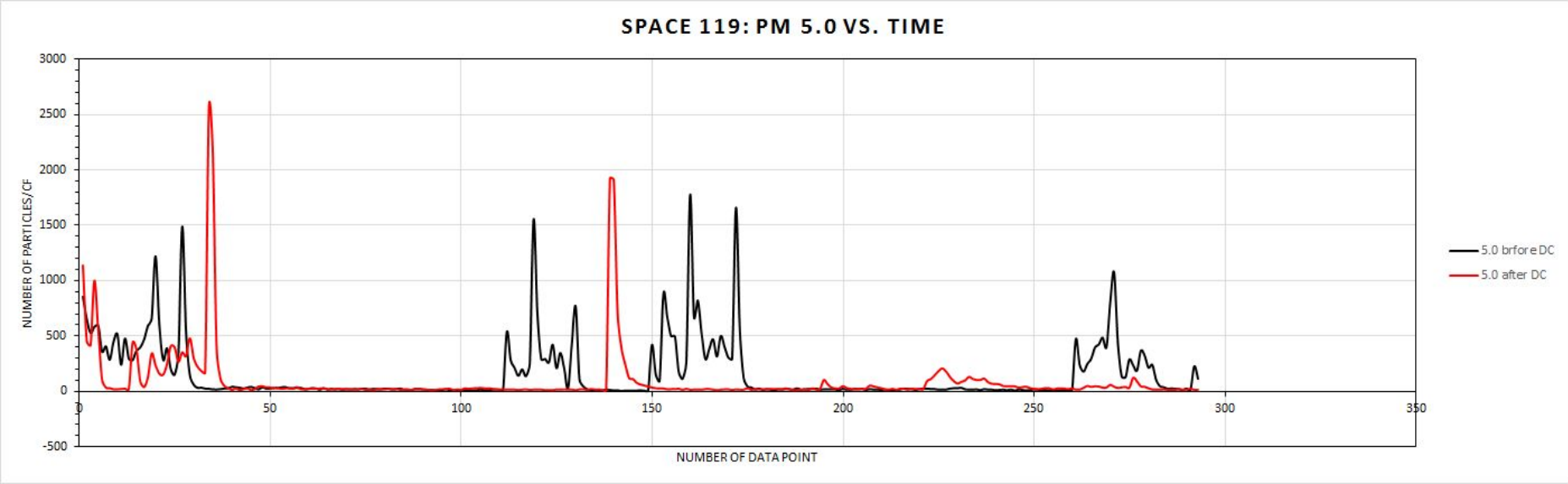
PM 1.0


SPACE 119: PM 1.0 VS. TIME
NUMBER OF PARTICLES/CF
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
50
100
150
200
250
300
350
NUMBER OF DATA POINT
1.0 brfore DC
1.0 after DC

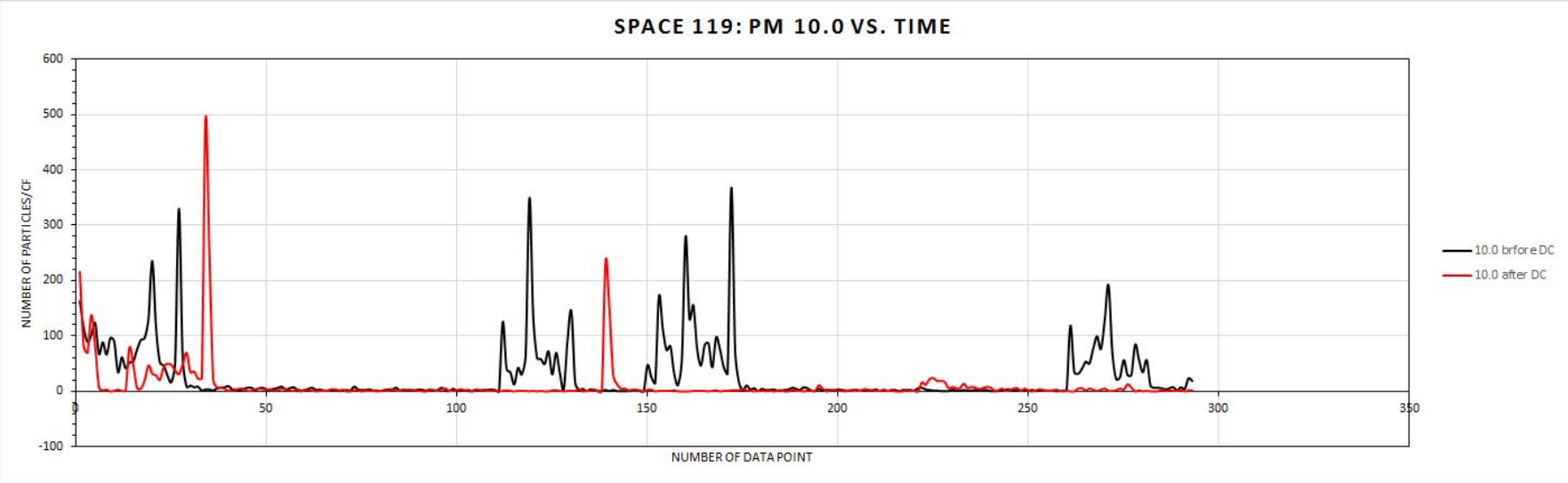
PM 2.0

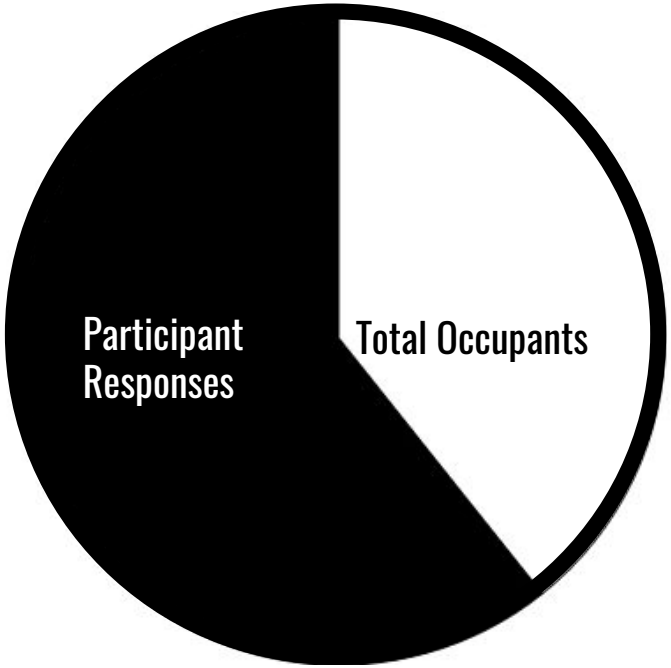

SPACE 119: PM 2.0 VS. TIME
NUMBER OF PARTICLES/CF
12000
10000
8000
6000
4000
2000
0
-2000
0
50
100
150
200
250
300
350
NUMBER OF DATA POINT
2.0 brfore
2.0 after

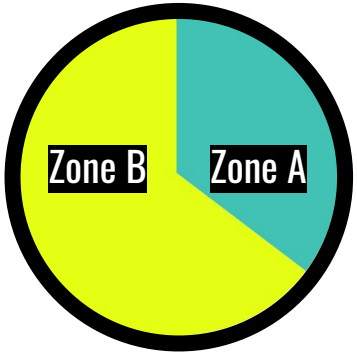
PM 5.0


SPACE 119: PM 5.0 VS. TIME
NUMBER OF PARTICLES/CF
3000
2500
2000
1500
1000
500
0
-500
0
50
100
150
200
250
300
350
NUMBER OF DATA POINT
5.0 brfore DC
5.0 after DC

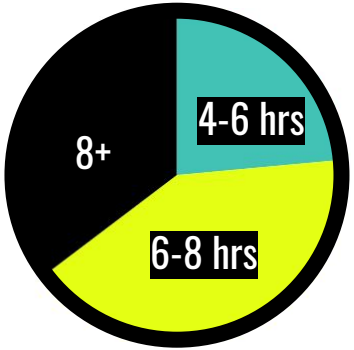
PM 10


SPACE 119: PM 10.0 VS. TIME
NUMBER OF PARTICLES/CF
600
500
400
300
200
100
0
-100
0
50
100
150
200
250
300
350
NUMBER OF DATA POINT
10.0 brfore DC
10.0 after DC

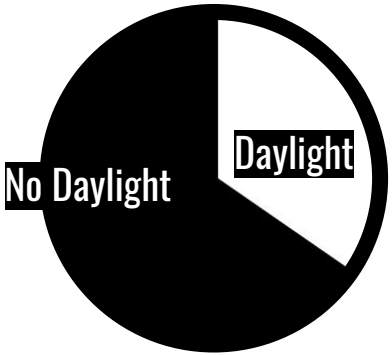




Total Response per Zone



Hours Worked



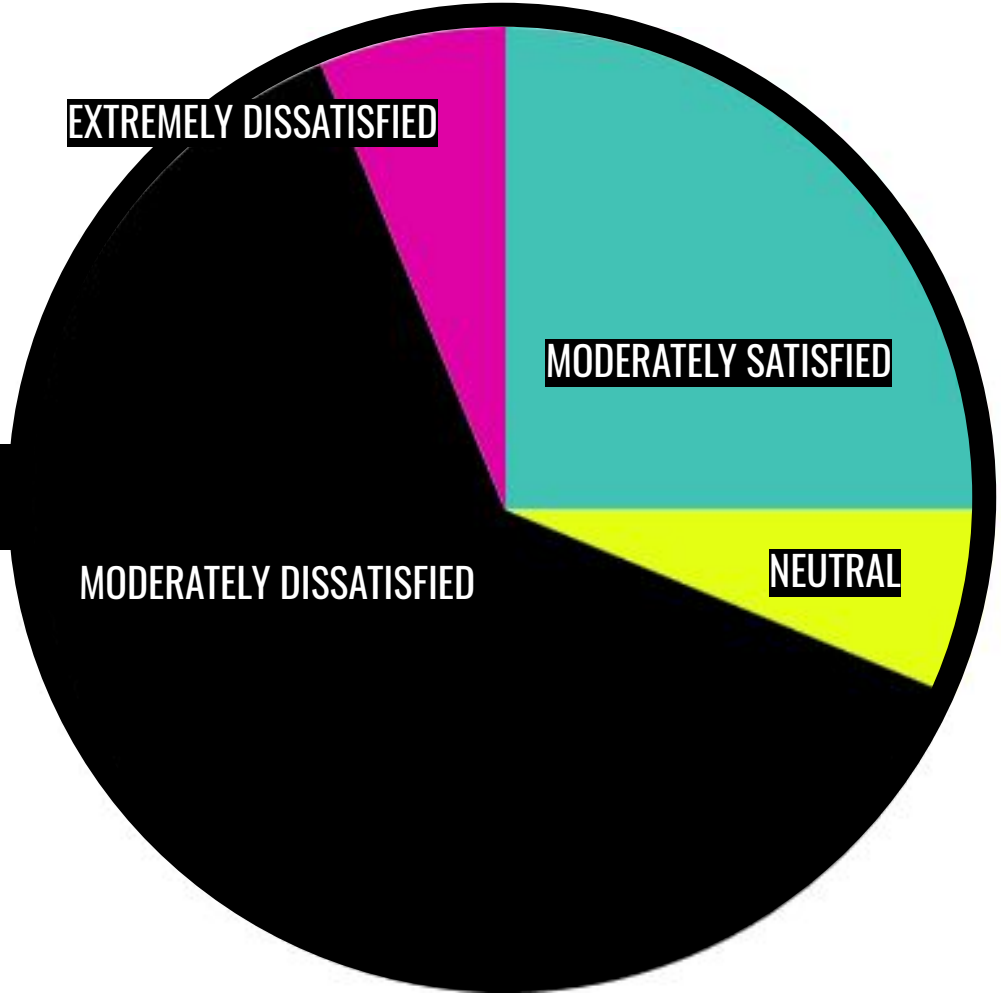
Work Spaces with Daylight Exposure

Participants with Daylight Exposure

Thermal Comfort

Please rate your satisfaction with the air temperature in your work space during the past month

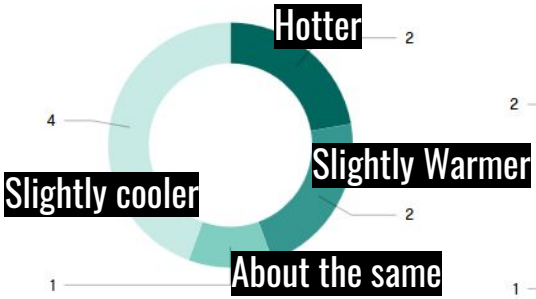
Thermal Comfort



Thermal Comfort

During the summer, I find that the air temperature in my work space is:

MONDAY



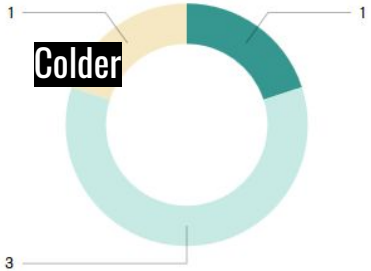
TUESDAY

WEDNESDAY

THURSDAY

DAILY

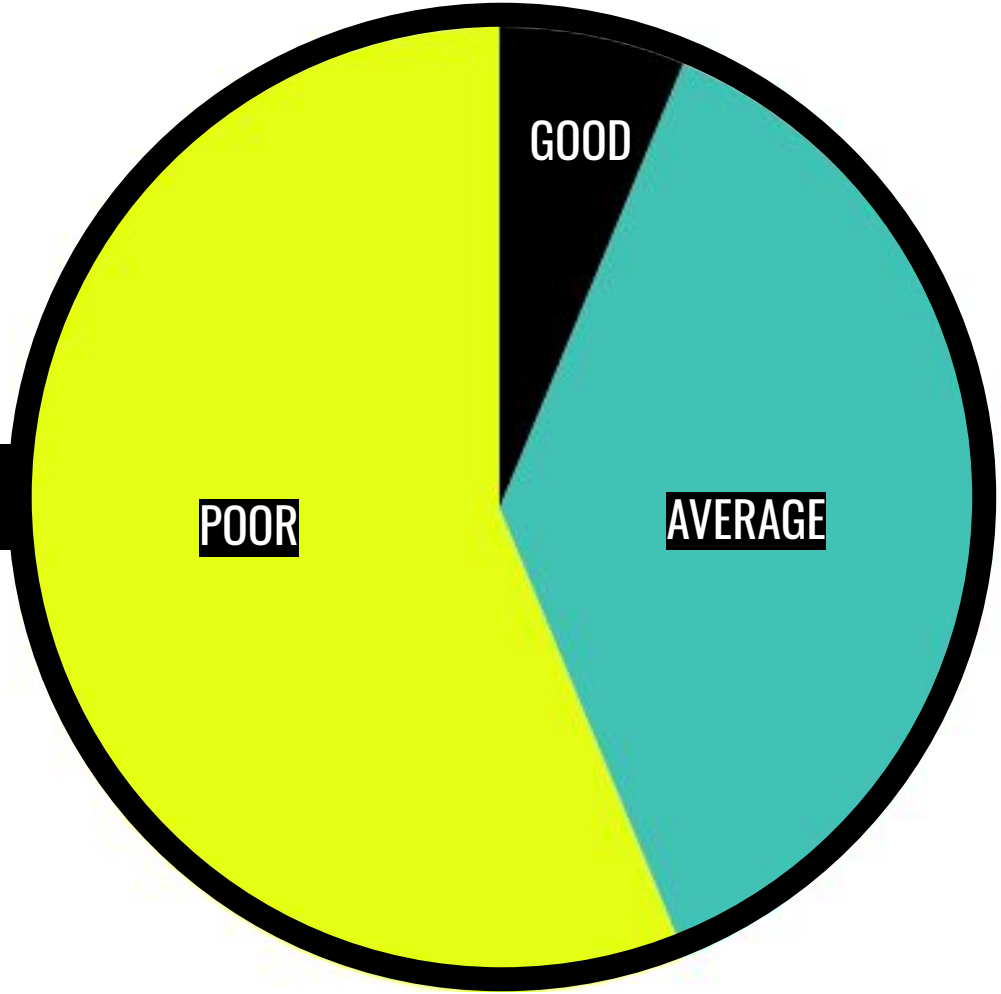
I HAVE NOT EXPERIENCES THIS SITUATION IN MY WORK SPACE



Indoor Air Quality

How would you rate the indoor quality in your work space?

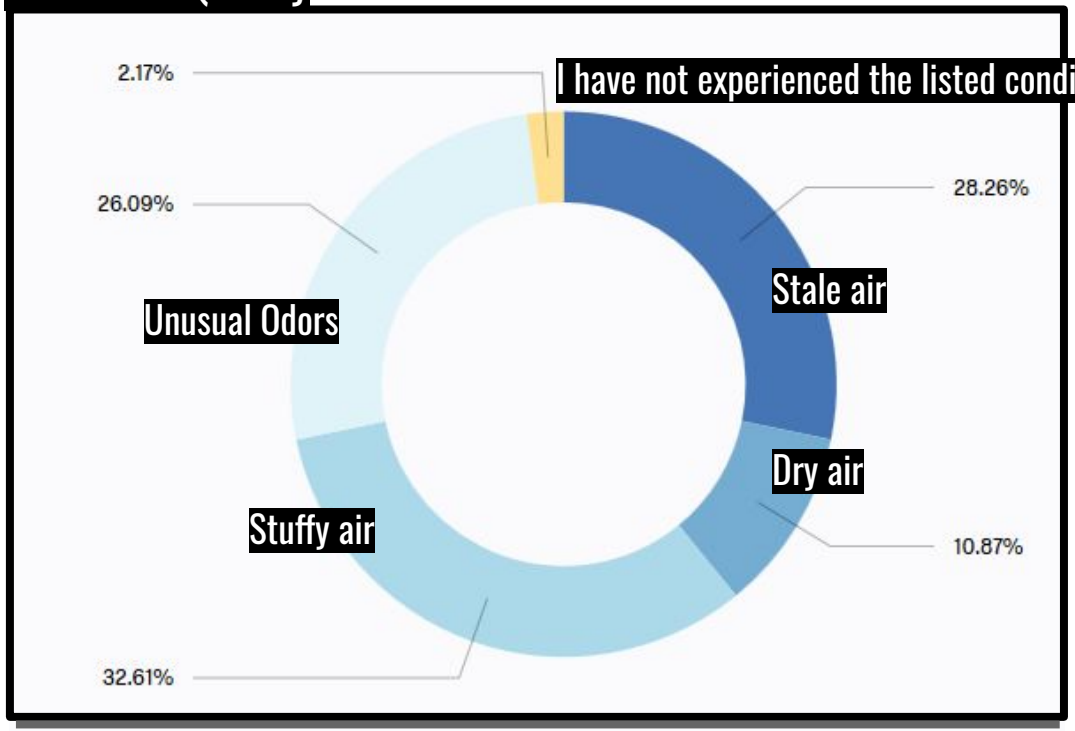
Indoor Air Quality

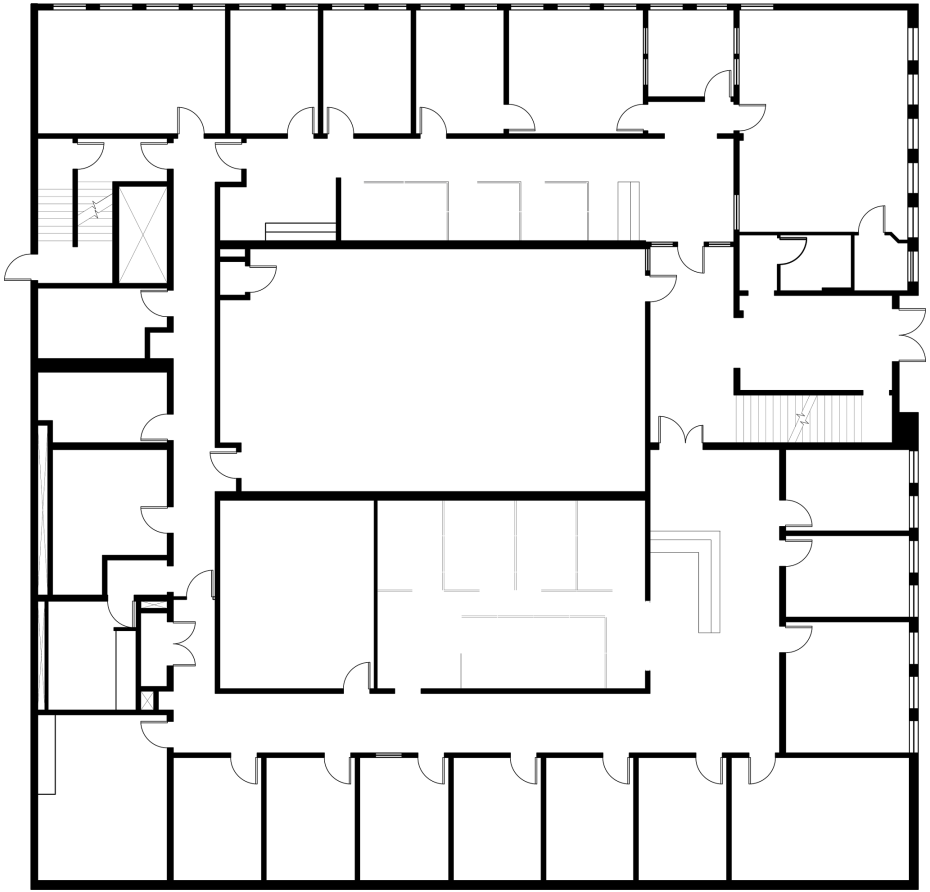


Indoor Air Quality

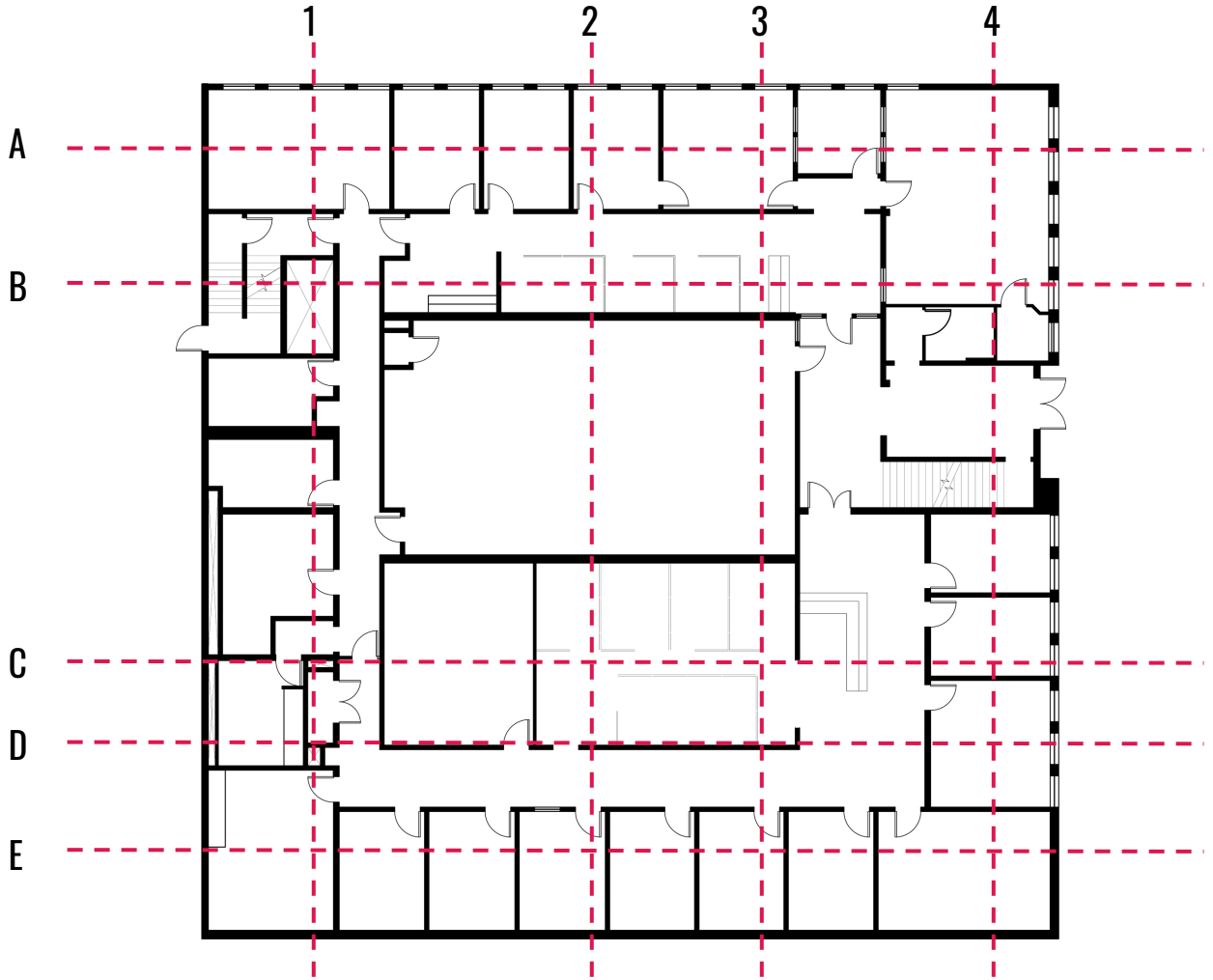
Have you experienced the following air quality conditions:

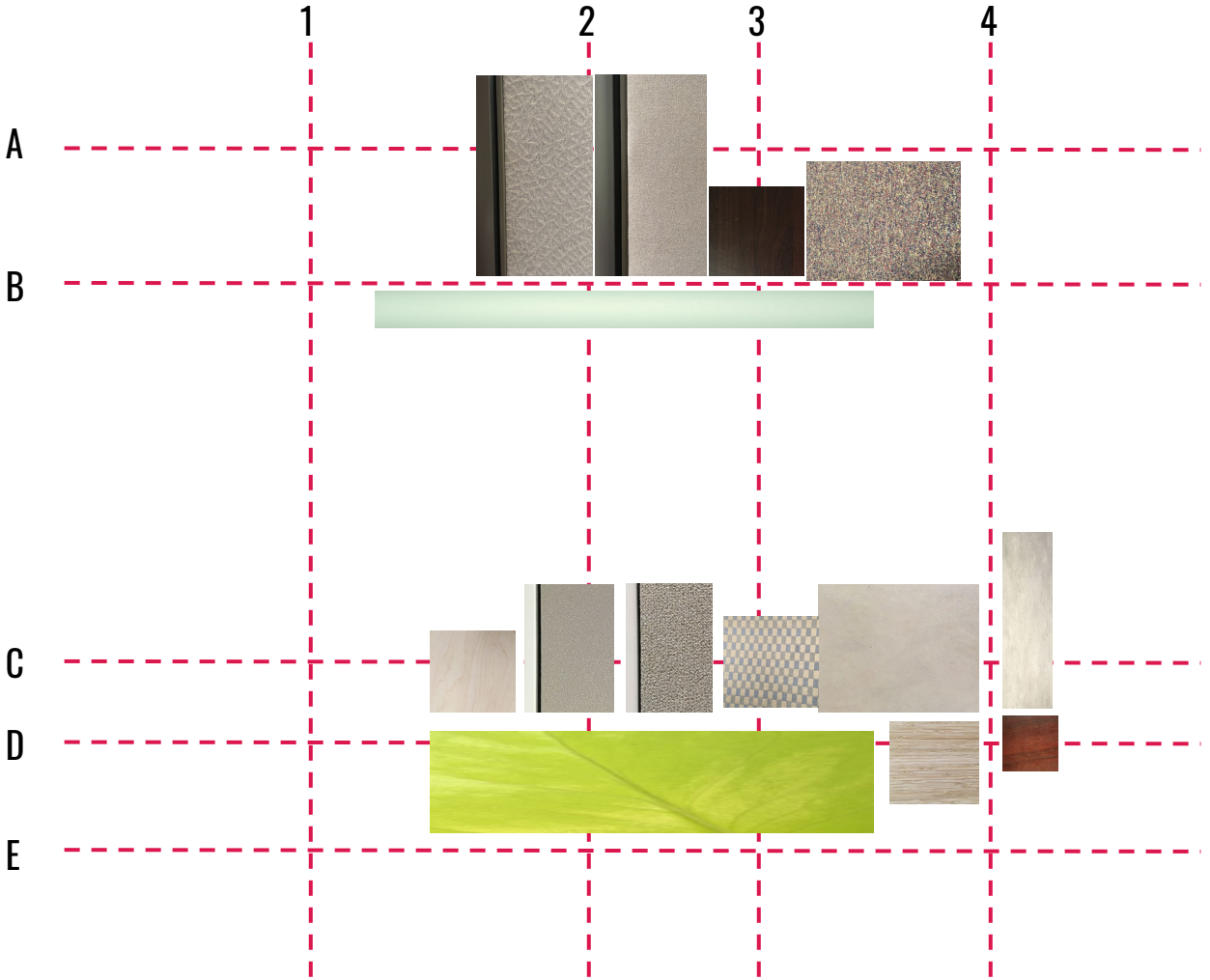
Indoor Air Quality

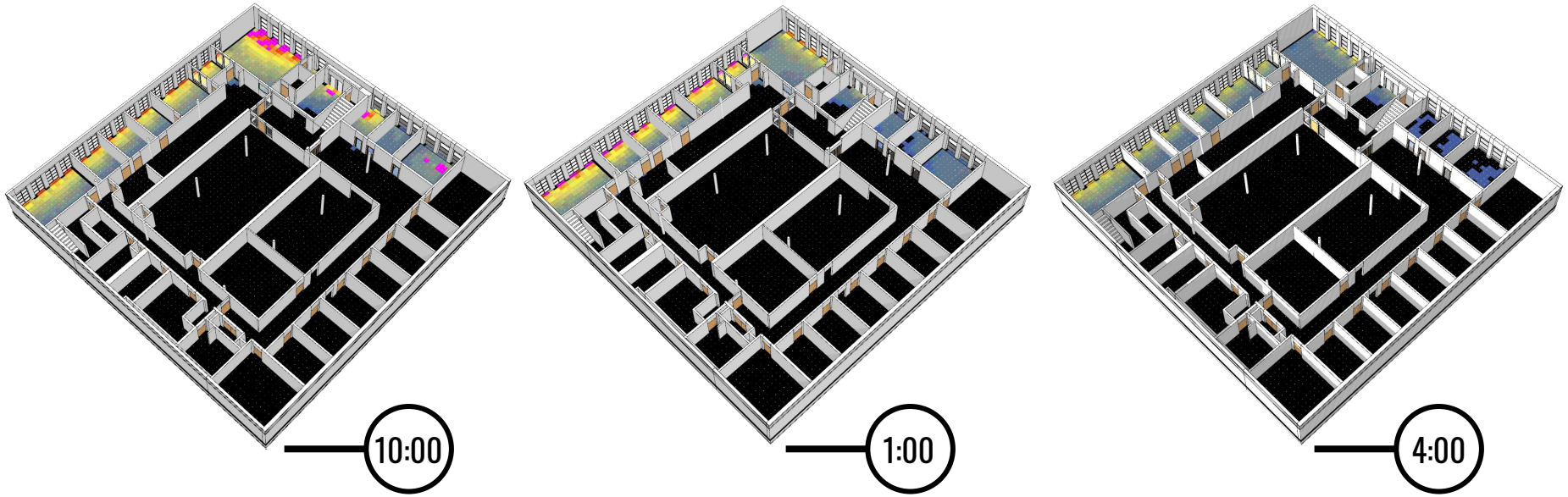




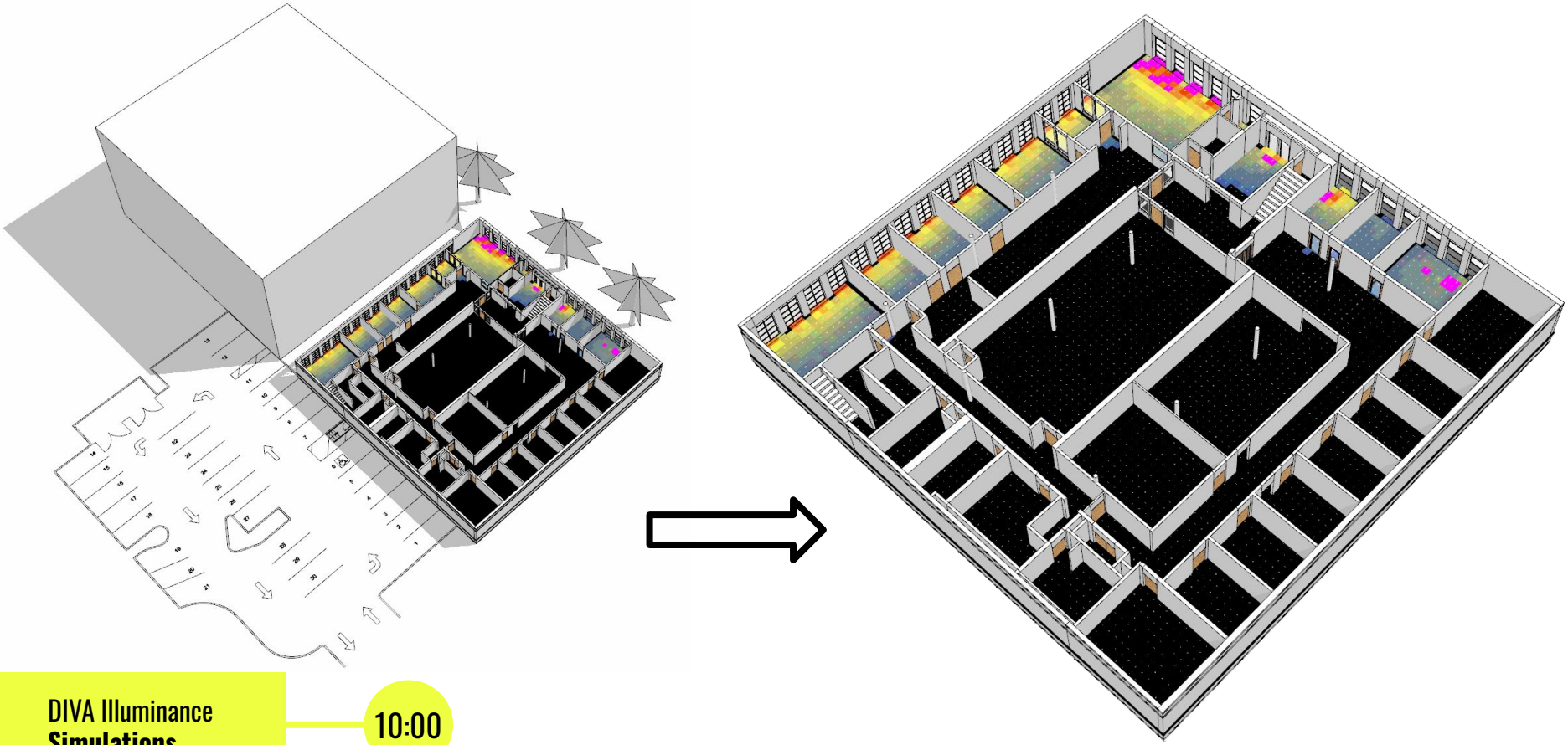
Work Space Environment
Materials


1
2
3
4
A
B
C
D
E


1
2
3
4
A
B
C
D
E

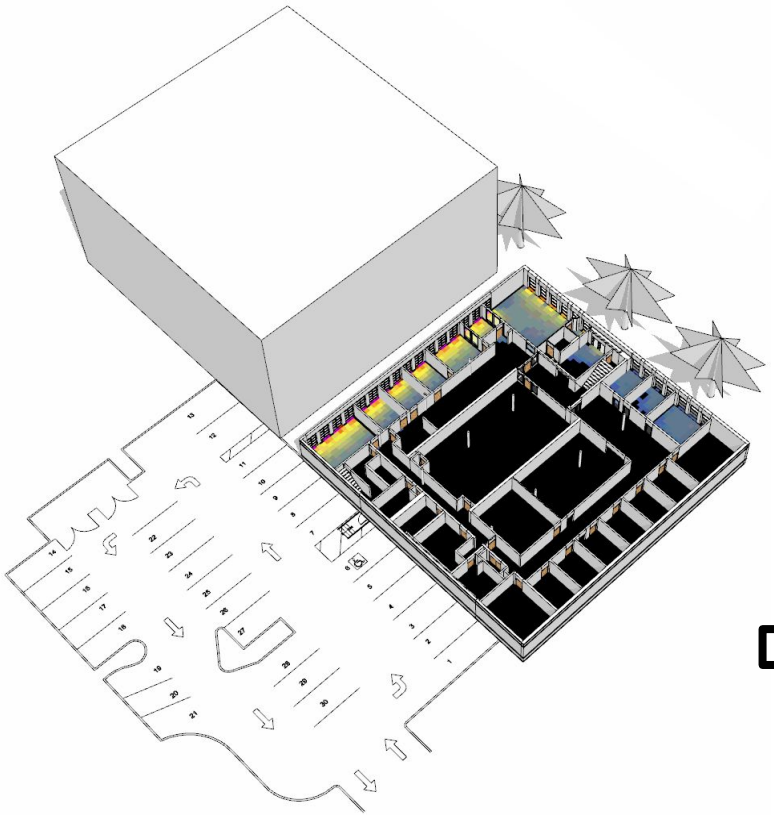


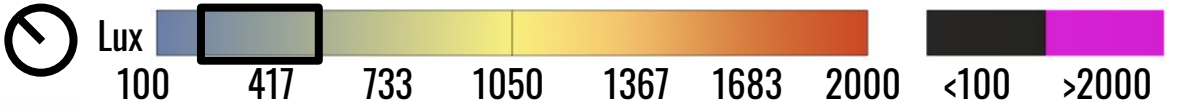
DIVA Illuminance
Simulations

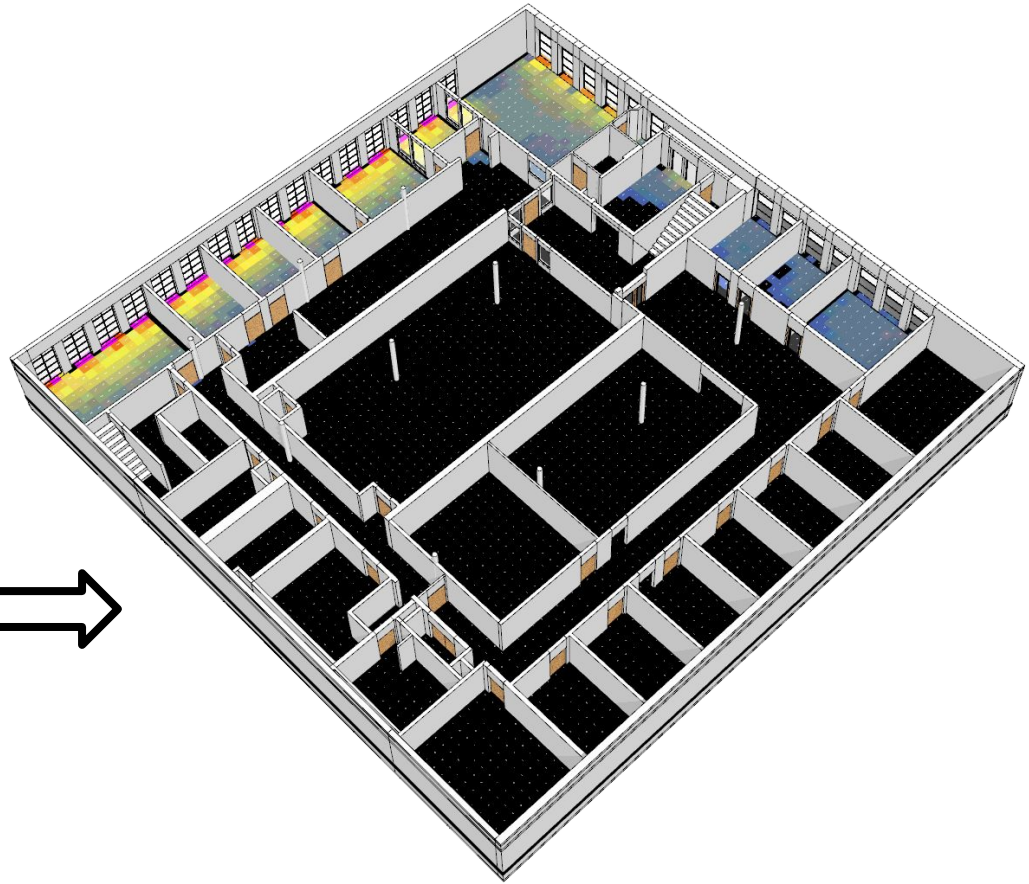


DIVA Illuminance
Simulations

10:00

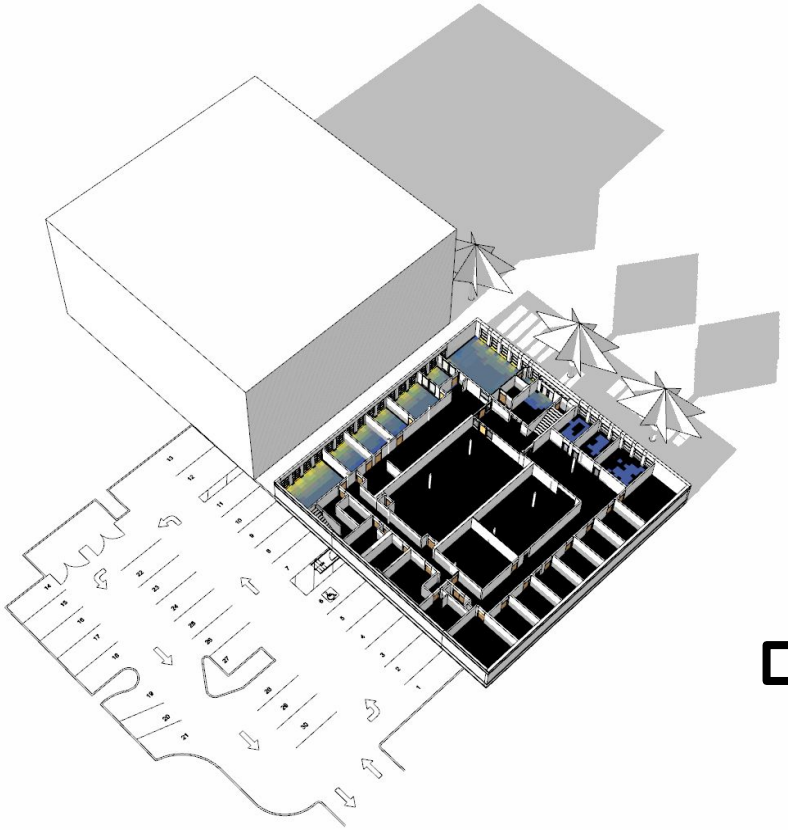


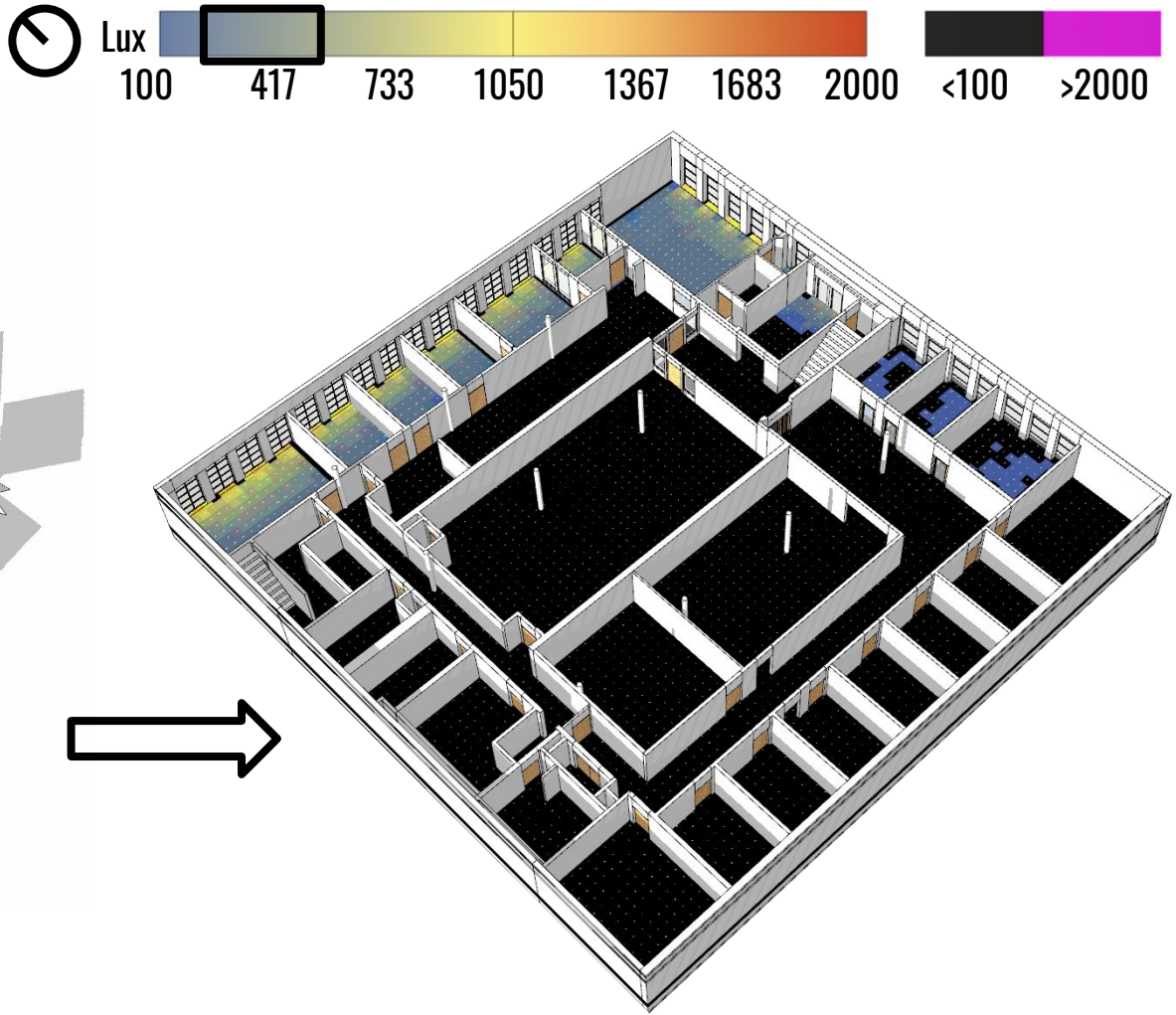




DIVA Illuminance
Simulations

1:00





DIVA Illuminance
Simulations

4:00

- Current: LED Wrap Lighting
- Past: Fluorescent Lighting
- Visualization: False-color

DIVA Illuminance
Visualization